

Nos. 2014-1087, 2014-1088

United States Court of Appeals
for the Federal Circuit

HAREN S. GANDHI, JOHN VITO CAVATAIO,
ROBERT HENRY HAMMERLE, YISUN CHENG,
Appellants,

v.

BRIGITTE BANDL-KONRAD, ANDREAS HERTZERG, BERND KRUTZSCH,
ARNO NOLTE, MARKUS PAULE, STEFAN RENFFTLEN,
NORBERT WALDBUESSER, MICHEL WEIBEL,
GUENTER WENNINGER, ROLF WUNSCH,
Cross-Appellants.

Appeal from the Patent Trial and Appeal Board in Interference No. 105,839,
Administrative Patent Judge Hung H. Bui.

BRIEF OF APPELLANTS

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January 13, 2014

CERTIFICATE OF INTEREST

I, E. Anthony Figg, Counsel for Appellants Haren S. Gandhi, John Vito Cavataio, Robert Henry Hammerle, and Yisun Cheng certify the following:

1. The full name of every party or amicus represented by me are Haren S. Gandhi, John Vito Cavataio, Robert Henry Hammerle, and Yisun Cheng.
2. Ford Global Technologies, LLC, One Parklane Blvd., Suite 600, Parklane Towers East, Dearborn, MI 48126 is the real party in interest.
3. All parent corporations and any publicly held companies that own 10 percent or more of the stock of the party or amicus curiae represented by me are: Ford Motor Company.
4. The law firms and the partners and associates that appeared for these parties in the trial court or are expected to appear in this court are:

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TABLE OF ABBREVIATIONS

Senior Party Gandhi	Haren S. Gandhi, John Vito Cavataio, Robert Henry Hammerle, and Yisun Cheng
Junior Party Bandl-Konrad	Brigitte Bandl-Konrad, Andreas Hertzerg, Bernd Krutzsch, Arno Nolte, Markus Paule, Stefan Renfflen, Norbert Waldbuesser, Michel Weibel, Guenter Wenninger, and Rolf Wunsch
Opinion	July 26, 2013 Opinion, <i>Brigitte Bandl-Konrad et al. v. Haren S. Gandhi et al.</i> , Patent Interference No. 105,839 (P.T.A.B.) (Paper No. 125)
Gandhi ‘558 application	U.S. Patent Application Serial No. 12/706,558
Bandl-Konrad ‘747 patent	U.S. Patent No. 7,814,747
Gandhi ‘470 application	U.S. Patent Application Serial No. 10/065,470, which published as U.S. Patent Application No. 2004/0076565
Khair ‘096 patent	U.S. Patent No. 6,293,096
Cooper ‘487 patent	U.S. Patent No. 4,902,487
Andreasson ‘809 application	WO Patent Application Publication No. 99/39809
Kaneko ‘883 patent	U.S. Patent No. 7,127,883
Kinugasa ‘024 patent	U.S. Patent No. 6,109,024
Twigg ‘647 application	PCT International Application No. 00/21647
Pieplu article	<i>Claus Catalysis and H₂S Selective Oxidation</i> by Anne Pieplu
NO _x	Nitrogen oxide
SCR	Selective catalytic reduction
SCR catalyst	“SCR catalytic converter” or “NH ₃ -SCR catalyst”
LNT	“Lean nitrogen oxide trap,” “nitrogen oxide storage catalytic converter,” “NO _x absorber catalytic converter,” NO _x trap,” “lean NO _x trap” or “lean NO _x absorber”
PTAB	Patent Trial and Appeal Board

STATEMENT REGARDING ORAL ARGUMENT

Senior Party, Gandhi, requests oral argument.

STATEMENT OF RELATED CASES

No previous appeals have been taken from this case to any appellate court.

Counsel is unaware of any cases pending in this or any other court that will directly affect or be affected by this Court's decision in this appeal.

JURISDICTIONAL STATEMENT

An Administrative Patent Judge declared an interference between Junior Party Bandl-Konrad's involved patent, the '747 patent, and Senior Party Gandhi's involved application, the '558 application. JA0007. The PTAB determined that claims 1-8, 10, 16-17 and 19 of Bandl-Konrad's '747 patent, were not shown to be unpatentable; cancelled claims 9, 11-15 and 18 of Bandl-Konrad's '747 patent; and refused all claims 9-13, 19, 20, 28, 30-35 and 46-49 of Gandhi's '558 application. JA0072-73. The PTAB entered final judgment accordingly. JA0075-77. Senior Party Gandhi timely filed a Notice of Appeal. JA1136-138. Junior Party Bandl-Konrad subsequently filed a Cross-Appeal. JA1139-141. This Court has jurisdiction under 28 U.S.C. § 1295(a)(4)(A).

STATEMENT OF ISSUES

1. Whether the PTAB erred in finding that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad '747 patent are not unpatentable, where the PTAB's basis for

finding the claims patentable, and the only difference between claims held patentable and unpatentable, is the placement of a feature taught by the prior art and the placement of the claimed feature is selected from one of only three potential options.

STATEMENT OF THE CASE

This appeal is from a patent interference declared by an Administrative Patent Judge between Senior Party Gandhi and Junior Party Bandl-Konrad.

The patent application and patent that were the subject of this interference, the Gandhi '558 application and the Bandl-Konrad '747 patent, are directed to systems and methods for purifying engine exhaust gas emissions using, among other components, an LNT, a downstream SCR catalyst, and alternating lean and rich conditions. During lean conditions, NO_x is stored in the LNT. During the periodic rich conditions, NO_x is released from the LNT and reduced by the rich exhaust gas. Ammonia is a by-product of the NO_x reduction. As recognized by these disclosures and the prior art, ammonia can be stored in a downstream SCR catalyst and subsequently used to reduce any NO_x that escapes through the LNT. Using this coupling of the LNT and SCR catalyst, one can efficiently lower exhaust emissions.

During the interference, Bandl-Konrad asserted that the claims of Gandhi's '558 application were unpatentable over two prior art references: the Kinugasa

‘024 patent and the Twigg ‘647 patent. The PTAB correctly found, and Bandl-Konrad did not dispute, that claims 9, 11-14 and 18 of Bandl-Konrad’s ‘747 patent were unpatentable over these same two prior art references. The PTAB also correctly found that claim 15 of Bandl-Konrad’s ‘747 patent was unpatentable over additional prior art on which Senior Party Ghandi relied, namely the ‘470 Gandhi application, the Khair ‘096 patent and the Pieplu article.

The PTAB erred, however, in determining that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad ‘747 patent (sometimes referred to herein as the “claims at issue” or the “disputed claims”) were not unpatentable. The only feature of the claims at issue that is not present in the claims that the PTAB found to be unpatentable over the prior art is directed to the location of a particulate filter. Particulate filters were well known components of exhaust gas systems, especially those used with diesel engines, as they reduce the emission of soot and other particulates. Indeed, the PTAB determined, as was undisputed by the parties, that particulate filters and their functionality were well known in the art. JA0054-55. Further, as admitted by Bandl-Konrad’s expert and acknowledged by the PTAB, a person of ordinary skill in the art would have added a particulate filter to an LNT and SCR catalyst structure according to known methods to yield predictable results. JA0054-55. In the claims at issue, it is the placement of the particulate

filter between the SCR catalyst and the LNT that the PTAB erroneously found to distinguish them from the prior art.

The PTAB erred in holding that the placement of the particulate filter relative to the SCR catalyst and LNT supported its legal conclusion of unobviousness. Given, as the PTAB found, that it would have been obvious to use a particulate filter in a system employing an SCR catalyst and an upstream LNT system, a person of ordinary skill in the art would have had only three possible options for placement of the particulate filter: (1) upstream of the LNT; (2) upstream of the SCR catalyst and downstream of the LNT; and (3) downstream of the SCR. The PTAB's determination that the location of the particulate filter was not obvious, in the face of uncontroverted evidence that there were a small, finite number of possible locations where a person of ordinary skill in the art could locate the particulate filter is contrary to common sense and to this Court's precedent.

During the interference proceedings, Bandl-Konrad successfully moved for a determination that the count and Gandhi's claims corresponding to the count were unpatentable over the Kinugasa and Twigg references. Bandl-Konrad's motion created a presumption under 37 C.F.R. § 41.207(c) that all of Bandl-Konrad's claims corresponding to the count, including the claims at issue in this appeal, are unpatentable over Kinugasa and Twigg. The PTAB erred in concluding that

Bandl-Konrad overcame this presumption, particularly in the absence of any evidence that the claimed location of the particulate filter produced any unexpected results or advantages over either of the other two possible locations.

The PTAB further erred in rejecting Senior Party Gandhi's contention that the claims at issue were unpatentable over additional prior art references presented by Senior Party Gandhi, including the related Gandhi '470 application and the Khair '096 patent in view of the level of ordinary skill in the art.

For these reasons, Senior Party Gandhi requests that the PTAB's patentability decision be reversed.

I. The Bandl-Konrad '747 Patent

A. The Claims Held Unpatentable by the PTAB

The PTAB held that claims 9, 11-14 and 18 of the Bandl-Konrad '747 patent are unpatentable. These claims are directed to methods for purifying exhaust gas emissions using, among other things, an oxidizing catalytic converter, an LNT, a downstream SCR catalyst, and alternating lean and rich conditions. *See* JA0102-103, claims. During lean conditions (*i.e.*, conditions in which there is a stoichiometric excess of air relative to fuel), carbon monoxide and hydrocarbons in the exhaust gas are oxidized in the oxidizing catalytic converter. JA0100 at col. 16, ll. 14-18; JA0097 at col. 9, ll. 2-8. Additionally, during lean conditions, NO_x is stored in the LNT. *See, e.g.*, JA0103, claim 9. During the periodic rich conditions,

NO_x is released from the LNT and reduced by the rich exhaust gas. *Id.* Ammonia is a major byproduct of the NO_x reduction. *See* JA0098 at col. 1, ll. 7-27. The Bandl-Konrad '747 patent recognized that ammonia can be stored in a downstream SCR catalyst and subsequently used for the selective reduction of any NO_x that happens to pass through the LNT. *See* JA0095 at col. 5, ll. 1-17.

Claim 9 of the Bandl-Konrad '747 patent is the only independent claim in the subset of claims that the PTAB held unpatentable. Claim 9 recites:

An exhaust gas aftertreatment method for purifying an exhaust gas of a diesel engine of a motor vehicle, said method comprising:

temporarily storing nitrogen oxides contained in the exhaust in a nitrogen oxide storage catalytic converter during adsorption operating phases;

releasing stored nitrogen oxides from the nitrogen oxide storage catalytic converter during regeneration operation phases, and thereby generating ammonia;

temporarily storing generated ammonia in an SCR catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter;

using the stored [*sic*, ammonia] for nitrogen oxide reduction in the SCR catalytic converter;

operating the combustion device under lean-burn conditions of the engine during adsorption operating phases;

during lean-burn conditions of the engine oxidizing carbon monoxide and hydrocarbons contained in the exhaust gas in an oxidizing catalytic converter arranged

as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas; and

operating the combustion device under rich-burn conditions during regeneration operating phases.

JA0102-103, claim 9.

Claims 11, 12 and 13 depend from claim 9. JA0103. Claim 11 adds “further comprising determining an exhaust air ratio downstream of the nitrogen oxide storage catalytic converter and terminating a regeneration operation phase if the determined exhaust air ratio drops below a threshold value.” JA0103, claim 11. Claim 12 adds “further comprising shifting a main fuel injection and/or an afterinjection of the engine towards a late position for enhancing an exhaust gas temperature.” JA0103, claim 12. Claim 13 adds “further comprising performing from time to time a desulfation of the nitrogen oxide storage catalytic converter.” JA0103, claim 13.

Claim 14 depends from claim 13 and adds “wherein an afterinjection of fuel is performed during the desulfation phases.” JA0103, claim 14. Claim 15 also depends from claim 13 and provides “wherein hydrogen sulphide formed during the desulfation phases is oxidized by the SCR catalytic converter.” JA0103, claim 15. Finally, claim 18 depends from claim 9 and adds “further comprising enhancing an NO₂-ratio of the nitrogen oxides in the exhaust gas by means of a

catalytic oxidation with an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.” JA0103, claim 18.

B. The Claims That the PTAB Held Not to Be Unpatentable

The PTAB determined that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad ‘747 patent were not unpatentable. Claims 1-8 are system claims directed to systems that embody the features of the above-described method claims. The claims require an oxidizing catalytic converter as a first aftertreatment component, followed by a LNT, a particulate filter, and finally an SCR catalyst. The only feature of claim 1 that is not present in claim 9 is “a particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter.” *Compare* JA0102-103, claim 1 *with* JA0103, claim 9.

Claim 1, in its entirety recites:

An installation for aftertreatment of exhaust gas generated by a diesel engine of a motor vehicle, said installation comprising:

a nitrogen oxide storage catalytic converter configured for temporarily storing nitrogen oxides contained in the exhaust gas during adsorption operating phases with a lean exhaust gas air ratio and, releasing and reducing stored nitrogen oxides during regeneration operating phases with a rich exhaust gas air ratio;

an SCR catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter, said SCR catalytic converter being configured to receive and store ammonia generated by the nitrogen oxide storage

catalytic converter, and to reduce nitrogen oxides in the exhaust gas with the stored ammonia;

a particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter; and

an oxidation catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas.

JA0102-103, claim 1. Claims 2, 3 and 4 depend from claim 1. JA0103. Claim 2 provides for a catalytic coating on the particulate filter. JA0103, claim 2. Claims 3 and 4 add additional components; in the case of claim 3, a NO₂ producing catalytic converter upstream of the SCR catalyst; and in the case of claim 4, a reducing agent supplying device that feeds fuel into the exhaust gas stream. JA0103, claims 2-4. Claim 5 depends upon claim 4 and provides for the location of the reducing agent supplying device to be upstream of the particulate filter. JA0103, claim 5.

Claims 6, 7 and 8 also depend from claim 1. JA0103. Claim 6 provides that the oxidation catalytic converter is arranged close to the engine. JA0103, claim 6. Claim 7 requires the additional feature of means for recording the NO_x content in the exhaust gas downstream of the LNT and/or downstream of the SCR catalyst. JA0103, claim 7. Claim 8 adds the additional feature of a lambda sensor arranged between the nitrogen oxide storage catalytic converter and the particulate filter.

JA0103, claim 8. Claim 19 adds the additional feature of an additional oxidation catalytic converter arranged downstream of the SCR catalyst. JA0103, claim 19.

Claims 10, 16 and 17 depend, either directly or indirectly from claim 9.

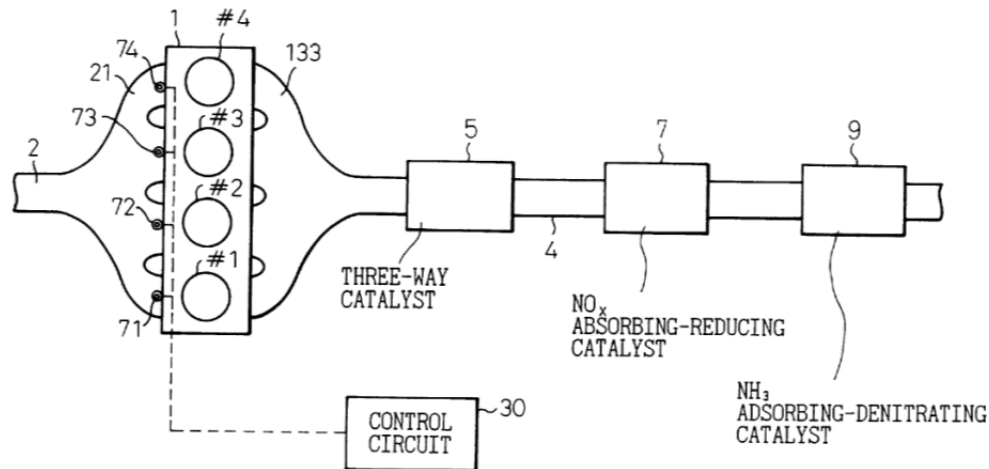
JA0103. Claim 10 depends directly from claim 9 and adds “further comprising filtering out particulates in the exhaust gas with a particulate filter arranged downstream of the nitrogen oxide storage catalytic converter and guiding filtered exhaust gas to the SCR catalytic converter.” JA0103, claim 10. Claim 16 depends from claim 10 and adds “further comprising performing from time to time a regeneration of the particulate filter.” JA0103, claim 16. Finally, claim 17 depends from claim 16 and adds “wherein an afterinjection of fuel is performed during the regeneration phases.” JA0103, claim 17.

II. The Prior Art

A. The Kinugasa ‘024 Patent

The Kinugasa ‘024 patent issued on August 29, 2000 and is prior art to the Bandl-Konrad ‘747 patent under 35 U.S.C. § 102(b). JA0038; JA2227. The Kinugasa ‘024 patent discloses an exhaust gas purification system for an internal combustion engine. JA0038; JA2257 at col. 1, ll. 7-8. The internal combustion engine is capable of removing NO_x in the exhaust gas of a lean burn engine with high efficiency. JA0038; JA2257 at col. 1, ll. 8-11.

Figure 1 of the Kinugasa '024 patent illustrates an exemplary exhaust gas purification system and is reproduced below:



JA2228. In the exhaust gas purification system of Figure 1, a three-way catalyst 5 is the first after treatment component in the flow of the exhaust gas. JA0039; JA2228. The three-way catalyst 5 of the Kinugasa '024 patent is the equivalent of an oxidizing catalytic converter. JA0039. The three-way catalyst receives exhaust gas from the engine and converts carbon hydrocarbons and carbon monoxide contained in the exhaust gas under lean conditions. JA0040; JA2260 at col. 7, ll. 6-11. At the time of the disclosure of the Kinugasa '024 patent, it was known that with excess oxygen, the three-way catalyst acts as an oxidation catalyst, removing all reducing species. JA0041; JA26446-671.

As illustrated in Figure 1 of the Kinugasa '024 patent, downstream of the three-way catalyst is an NO_x absorbing-reducing catalyst 7. JA2259 at col. 5, ll.

55-63. The NO_x absorbing-reducing catalyst is the equivalent of an LNT.

JA0039-40. The NO_x absorbing-reducing catalyst receives exhaust gas from the three-way catalyst absorbs and stores NO_x in rich conditions. JA0041; JA 2260 at col. 8, ll. 13-20.

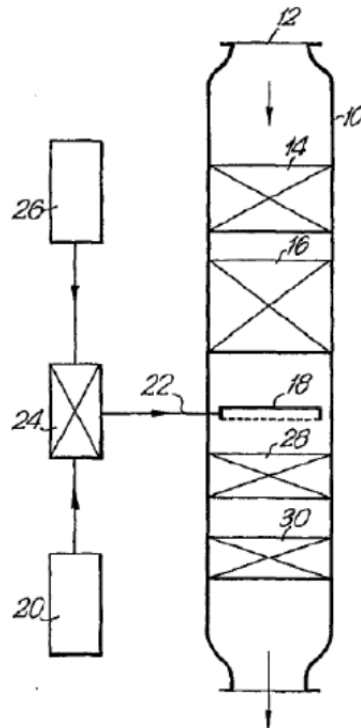
Further downstream of the NO_x absorbing-reducing catalyst is an NH₃ adsorbing-denitrating catalyst that adsorbs any ammonia that is generated and uses the adsorbed ammonia to reduce NO_x in the exhaust gas. JA0042; JA 2260 at col. 9, ll. 13-6, 42-44.

The Description of the Relevant Art section of the Kinugasa '024 patent discloses that it was known prior to the invention of the Kinugasa '024 patent that engine cylinders could be operated with rich air-fuel ratios. JA0040; JA2257 at col. 1, ll. 45-49. The Kinugasa '024 patent further discloses that the fuel injection valves can be controlled so that the engine cylinders include alternating lean and rich air-fuel ratios. JA0040; JA2257-58 at col. 2, l. 5 – col. 3, l. 10. The Kinugasa '024 patent further discloses controlling engine operations to generate lean and rich air-fuel ratios. JA0040; JA2259, col. 6, ll. 18-26.

B. The Twigg '647 Application

The Twigg '647 application is prior art to the Bandl-Konrad '747 patent under § 102(b). The Twigg '647 application is directed to systems and methods for the control of emissions of a diesel engine exhaust. JA0042; JA2482, Abstract.

One embodiment of the systems disclosed in the Twigg '647 application is illustrated in Figure 1, reproduced below.



JA2498.

In Figure 1 of the Twigg '647 application, the system comprises a catalyst 14 that converts NO to NO₂. JA0043; JA2490 at ll. 25-27. Downstream of the catalyst is a particulate filter 16 that collects particles. JA2490 at ll. 29-31. The Twigg '647 application describes that filtering particulate matter is a well-known and common technique used in exhaust gas purification systems. JA0043; JA2486 at ll. 6-15. Further, the filtration of particulate matter is particularly common in systems that comprise engines consuming diesel fuel, such as the systems disclosed by the Kinugasa '024 patent. JA0043; JA2486 at ll. 6-15. Downstream

of the particulate filter is a NO_x absorber 28. JA0043; JA2491 at ll. 8-12. Finally, a three-way catalyst 30 that passes exhaust gases is located downstream of the NO_x absorber. JA0043; JA2491 at ll.12-17.

C. The Gandhi '470 Application

The Gandhi '470 application is a grandparent application of the Gandhi '558 application that is the subject application of the interference. JA0057. Like the Gandhi '558 application, the Gandhi '470 application is directed to systems and methods for purifying exhaust gas emissions. JA1211 at ¶ [0002]. The purifying exhaust gas emissions systems comprise LNTs and SCR catalysts. JA0058; *see, e.g.*, JA1205, Figure 2.

Figure 2 illustrates one embodiment of the Gandhi '470 application.

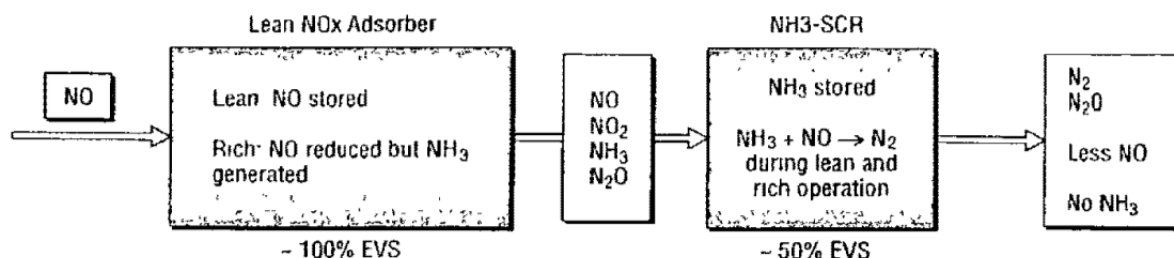


Fig. 2

JA1205, Figure 2. The Gandhi '470 application discloses temporarily storing NO_x in the Lean NO_x Trap during lean conditions of the adsorption operating phase, and releasing and reducing NO_x during the rich conditions of the regeneration phase, and thereby generating ammonia. JA0058; JA1213 at ¶ [0033]. In the Gandhi '470 application, the ammonia is received and stored by the downstream SCR Catalyst

and subsequently used to reduce NO_x in the SCR catalyst during lean conditions of the adsorption operating phase. JA0058; JA1213 at ¶ [0033]. The Gandhi '470 application expressly teaches that this combination of the LNT and SCR catalyst is preferred. JA0058; 1214 at ¶ [0044]. Specifically, the Gandhi '470 application provides:

The advantage of the catalyst system of this invention is the *use of a combination of a lean NO_x trap and an NH₃-SCR catalyst*. The use of a lean NO_x trap in the present system allows for much greater storage of NO_x, because the NO_x breakthrough that would otherwise happen can be controlled by the NH₃-SCR catalyst. Additionally, the use of a lean NO_x trap as part of this system allows for the operation of the engine at lean conditions for a longer time, and thus provides improved fuel economy Thus the combination of a lean NO_x trap and NH₃-SCR catalyst allows for significant NO_x storage and ammonia production and thus increases net NO_x conversion.

JA0058; JA1214 at ¶ [0044].

The Gandhi '470 application also discloses a three-way catalyst for oxidizing carbon monoxide and hydrocarbons contained in the exhaust gas. JA0060; JA1210, Figure 9. The three-way catalyst is arranged as the first exhaust gas aftertreatment component and is positioned in close proximity to the engine to reduce cold start emissions. JA0060; JA1210, Figure 9.

In certain embodiments of the Gandhi '470 application, the LNT and SCR catalyst are separate components. JA0058; JA1205, Figure 2. In other

embodiments of the Gandhi '470 application, however, the LNT and SCR catalyst are adjacent to one another and arranged on a single substrate or single catalytic converter can. JA0058-59; JA1206, Figure 4; JA1209, Figure 7.

D. The Khair '096 Patent

The Khair '096 patent issued on September 25, 2001 and is prior art under 35 U.S.C. § 102(b). JA0061. The Khair '096 patent describes a system and method for purifying exhaust gas. JA1222, col. 2, ll. 17-21. The system comprises a first stage for oxidizing NO to NO₂, a second stage for reducing a portion of NO₂ to N₂, and a third stage for reducing the remaining portion of NO₂ to N₂ and for reducing oxide carbon to CO₂. JA0061; JA1222, col. 1, ll. 5-12.

Figure 1, reproduced below in annotated form, provides an exemplary multiple stage after treatment system of the Khair '960 patent.

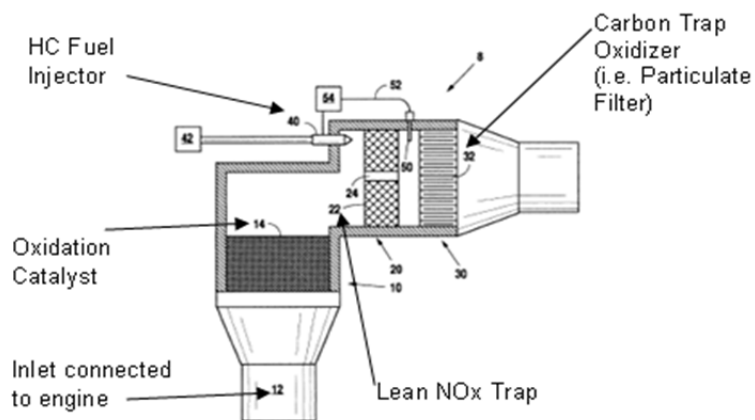


Fig. 1

JA0061-62; JA1220, Figure 1. In the system depicted in Figure 1, an inlet 12 is adapted to receive exhaust gases from an internal combustion engine. JA0061-62;

JA1220, Figure 1; JA1223, col. 4, ll. 20-22. An oxidation catalyst 14 receives the exhaust gases and oxidizes components of the NO_x to form nitrogen oxide and discharge a gaseous stream that contains nitrogen oxide and particulate matter.

JA0061-62; JA1220, Figure 1; JA1223, col. 4, ll. 20-22. An LNT reduces a portion of the nitrogen oxide to N₂ and O₂. JA0061-62; JA1220, Figure 1; JA1223, col. 4, ll. 38-54. The system of Figure 1 also includes a particulate filter (referred to in the Khair '096 patent as a carbon trap oxidizer) that is located downstream of the LNT. JA0062; JA1222-23, col. 2, l. 39 – col. 3, l. 4.

The Khair '096 patent teaches that the arrangement in Figure 1 combines the functions of a particulate filter, an LNT and a carbon trap in a single system for the reduction of NO_x and particulate matter emissions. JA0061-62; JA1223, col. 4, ll. 4-10. The particulate filter collects particulates on a filter and then combusts the particulates using NO₂, thereby regenerating the filter and allowing it to collect more particulate. JA0061-62; JA1223, col. 4, ll. 38-53.

The Khair '096 patent discloses that the particulate filter can be arranged in multiple positions in an exhaust gas purification system. JA1220; JA1221. In the first preferred embodiment disclosed in the Khair '096 patent, the particulate filter is arranged downstream of the LNT. JA0062; JA1220, Figure 1. In a second embodiment disclosed in the Khair '096 patent, the particulate filter is arranged upstream of the LNT. JA0063; JA1221; JA1153 at ¶ 28. In both embodiments,

however, a desirable reduction of NO_x and particulate matter in the exhaust system is achieved. JA0063; JA1224, col. 5, ll. 53-59.

E. Knowledge Possessed by Persons of Ordinary Skill in the Art

The PTAB defined a person of ordinary skill in the art as a person having “a bachelor’s degree in chemistry, mechanical engineering, automotive engineering, or chemical engineering and seven years’ work in the field, or a master’s degree in chemistry, mechanical engineering, automotive engineering, or chemical engineering and five years’ work experience in the field.” JA0046. Senior Party Gandhi does not dispute this definition.

Prior to the alleged invention disclosed in the Bandl-Konrad ‘747 patent, it was well known to persons of ordinary skill in the art that fuel injection could be controlled to raise the exhaust gas temperature for periodically performing a desulfation operation for exhaust gas purifying systems. JA0063; JA1312-1332. Further, it was known to a person of ordinary skill in the art that catalysts are used to oxidize, during a desulfation, hydrogen sulphide (H₂S) present in the exhaust gas and that it was well known in the art that various materials such as activated carbons, zeolites, silica, alumina, and other metal oxides were effective at catalyzing the oxidation of H₂S. JA0063; JA1333-1374.

SUMMARY OF ARGUMENT

The PTAB's failure to find that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad '747 patent are unpatentable was legal error. The underlying material facts – the scope and content of the prior art, the differences between the prior art and the claimed invention, the level of ordinary skill and any secondary indicia of unobviousness¹ – are not in dispute. The PTAB's legal conclusion of unobviousness based on these facts was erroneous.

In its decision, the PTAB determined that all of the features of those claims were in the prior art except for one feature: the location of the particulate filter in relation to the LNT and the SCR catalytic converter. In fact, the PTAB held that claims similar to these claims with all of these claimed features except for the particulate filter were unpatentable in view of the prior art. Specifically, the PTAB held that claims 9, 11-15 and 18 of the Bandl-Konrad '747 patent were unpatentable over of the prior art.

The PTAB's determination that the location of the particulate filter could impart patentability to this subset of the claims of the Bandl-Konrad '747 patent is based on legal error. In its decision, the PTAB acknowledged that the inclusion of particulate filter and a filtering technique in a prior art exhaust gas purification

¹ Junior Party Bandl-Konrad did not assert any secondary indicia of unobviousness in support of the patentability of the claims of the Bandl-Konrad '747 patent over the prior art.

system “would involve nothing more than an obvious combination of prior art elements according to known methods to yield predictable results.” Despite this determination, the PTAB held that the specific location of this particulate filter, as defined in the claims at issue, could provide sufficient grounds for patentability. The location of the particulate filter, however, is nothing more than an obvious design choice selected from a small, finite number of possible arrangements. There is no evidence that this particular arrangement of components produces any unexpected results or advantages over the other possible arrangements.

As acknowledged by the PTAB and disclosed in the prior art, exhaust gas purification systems were known in the prior art. Furthermore, prior art systems included an LNT upstream of an SCR catalyst. Therefore, the only difference between the prior art systems and the claimed systems of the Bandl-Konrad ‘747 patent is the location of a particulate filter between the LNT and the SCR catalyst. The prior art discloses particulate filters located in various positions in exhaust gas purification systems. A person of ordinary skill in the art would have understood that only a small, finite number of possible locations for inclusion of a particulate filter exist, namely upstream of the LNT, between the LNT and SCR, and downstream of the SCR. The fact that a person of ordinary skill in the art would have had only three possible options for placing a particulate filter necessitates a

conclusion that this feature cannot impart patentability to the claims of the Bandl-Konrad '747 patent.

Thus, the PTAB erred in holding that Bandl-Konrad overcame the presumption under 37 C.F.R. § 41.207(c) that certain claims were patentable over Kinugasa and Twigg. Additionally, the PTAB erred in rejecting Senior Party Gandhi's contention that these certain claims of Bandl-Konrad's '747 patent were unpatentable over additional prior art references presented by Senior Party Gandhi, including the related Gandhi '470 application, the Khair '096 patent in view of the level of ordinary skill in the art.

The PTAB further erred in determining that the Gandhi '470 application would have discouraged a person of ordinary skill in the art from arriving at the claimed invention. In reaching this conclusion, the PTAB relied exclusively on statements directed to a single embodiment disclosed in the Gandhi '470 application rather than considering the entirety of the Gandhi '470 application. Not only do the statements upon which the PTAB relied fail to teach away from the claimed invention, but these statements merely disclose alternative embodiments that are dissimilar in certain respects to the claimed invention. Under this Court's precedent, a mere disclosure of alternative embodiments without criticism of discouragement from using the claimed embodiment does not amount to teaching away.

Similarly, the PTAB erroneously relied on statements directed to preferred embodiments of the Gandhi ‘470 application. Simply because the Gandhi ‘470 application discloses preferred embodiments that differ in certain respects from the claimed invention does not mean that the Gandhi ‘470 application teaches away from the claimed invention. Rather, all of the embodiments disclosed in the Gandhi ‘470 application, even inferior embodiments, are relevant to the obviousness inquiry. Thus, the PTAB erred in determining that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad ‘747 patent were patentable.

ARGUMENT

I. The PTAB Erred in Concluding that Claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad ‘747 Patent Were Not Unpatentable

A. Legal Standards and Standard of Review

1. Presumption of Unpatentability Under 37 CFR § 41.207(c)

In a patent interference, a party moving for judgment based on prior art must also rebut the presumption that the prior art does not render the moving party’s claims unpatentable. *See Navarrini v. Worm*, No. 105,130, 2005 WL 4163624, 79 USPQ2d 1178, 1183 (BPAI 2005). Pursuant to 37 C.F.R. § 41.207(c):

When a motion for judgment of unpatentability against an opponent’s claim on the basis of prior art is granted, each of the movant’s claims corresponding to the same count as the opponent’s claim will be presumed to be unpatentable in view of the same prior art unless the movant in its motion rebuts this presumption.

2. Obviousness

A patent claim is unpatentable “if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art....” 35 U.S.C. § 103(a); *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 418, 426-27 (2007). Obviousness is a question of law based on underlying factual inquiries. *KSR*, 550 U.S. at 406. The factual inquiries include the scope and content of the prior art, the differences between the prior art and the claims, the level of ordinary skill in the art, and secondary considerations of nonobviousness. *Graham v. John Deere Co.*, 383 U.S. 1, 17-18 (1966); *Media Techs. Licensing, LLC v. Upper Deck Co.*, 596 F.3d 1334, 1337 (Fed. Cir. 2010).

The obviousness inquiry asks “whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue.” *KSR*, 550 U.S. at 418. Motivation to combine is a question of fact. *Wyers v. Master Lock Co.*, 616 F.3d 1231, 1239-40 (Fed. Cir. 2010). When there are “a finite number of identified, predictable solutions” and “a person of ordinary skill has good reason to pursue the known options within his or her technical grasp,” those solutions would have been obvious. *KSR*, 550 U.S. at 421; *see also Bayer Schering Pharma AG v. Barr Labs., Inc.*, 575 F.3d 1341, 1350 (Fed. Cir. 2009) (holding that where the prior art would have “funneled” a person of ordinary skill

in the art to two options, the claimed invention was obvious). “If a person of ordinary skill can implement a predictable variation [of a work available in the prior art], § 103 likely bars its patentability.” *KSR*, 550 U.S. at 417. The motivation to modify the prior art can be derived from “design incentives and other market forces” as well as from teachings in the literature. *Id.* at 417. “[T]he simple substitution of one known element for another or the mere application of a known technique to a piece of prior art ready for the improvement” should ordinarily result in a straightforward finding of obviousness. *Id.* at 417.

“[W]hen the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious.” *KSR*, 550 U.S. at 416 (*citing United States v. Adams*, 383 U.S. 39, 40 (1966)). A determination as to whether a reference teaches away from a claimed invention is a question of fact. *See In re Napier*, 55 F.3d 610, 613 (Fed. Cir. 1995). “A reference may be said to teach away when a person of ordinary skill, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the applicant.” *In re Icon Health & Fitness, Inc.*, 496 F.3d 1374, 1381 (Fed. Cir. 2007); *In re Gurley*, 27 F.3d 551, 553 (Fed. Cir. 1994). “A reference does not teach away, however, if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage

investigation into the invention claimed.” *Galderma Labs., L.P. v. Tolmar, Inc.*, 737 F.3d 731, 738 (Fed. Cir. 2013); *see also In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004) (“mere disclosure of alternative designs does not teach away.”). Additionally, “just because better alternatives exist in the prior art does not mean that an inferior combination is inapt for obviousness purposes.” *In re Mouttet*, 686 F.3d 1322, 1333-34 (Fed. Cir. 2012).

Secondary considerations are findings of fact; they include unexpected results, long-felt need, commercial success, and industry recognition. *Graham*, 383 U.S. at 17-18; *Ecolochem, Inc. v. S. Cal. Edison Co.*, 227 F.3d 1361, 1376 (Fed. Cir. 2000). These factors must be considered but they do not control the obviousness inquiry. *Newell Cos. v. Kenney Mfg. Co.*, 864 F.2d 757, 768 (Fed. Cir. 1988). A strong case for obviousness may not be outweighed by the secondary considerations. *See, e.g., KSR*, 550 U.S. at 413, 426; *Wm. Wrigley Jr. Co. v. Cadbury Adams USA LLC*, 683 F.3d 1356, 1363 (Fed. Cir. 2012).

Obviousness is a legal conclusion that this Court reviews *de novo*. *Novo Nordisk A/S v. Caraco Pharm. Labs., Ltd.*, 719 F.3d 1346, 1354 (Fed. Cir. 2013). Underlying factual findings made by the PTAB are reviewed for under the substantial evidence standard pursuant to the Administrative Procedures Act. 5 U.S.C. § 706(2)(A); *Dickinson v. Zurko*, 527 U.S. 150, 162 (1999).

B. The PTAB Erroneously Held that Bandl-Konrad Overcame the Presumption that Claims 1-8, 10, 15-17 and 19 Were Unpatentable Over the Kinugasa '024 Patent and the Twigg '647 Application

During the interference, Junior Party Bandl-Konrad asserted that the count and Senior Party Gandhi's claims corresponding to the count were unpatentable over the prior art including the Kinugasa '024 patent and the Twigg '647 application. JA0036-37. The PTAB agreed with Junior Party Bandl-Konrad's argument, and Senior Party Gandhi does not dispute, that the count and the claims of the Gandhi '558 application would have been obvious over the Kinugasa '024 patent and the Twigg '647 application. JA0070-71. Because the PTAB determined that the claims of the Bandl-Konrad '747 patent corresponded to the count, however, those claims were presumed to be unpatentable in view of the prior art. *See* 37 C.F.R. § 41.207(c). The PTAB erred in reaching the conclusion that Junior Party Bandl-Konrad overcame the presumption of unpatentability.

The PTAB erred in holding that the location of a particulate filter upstream of an SCR catalyst and downstream of an LNT imparted patentability to claims 1-8, 10, 15-17 and 19 of the Bandl-Konrad '747 patent. The PTAB acknowledged that all of the features except for the location of the particulate filter were disclosed by the prior art. JA0052-56. In fact, that factual finding was vital to the PTAB's determination that claims 9, 11-15 and 18 of the Bandl-Konrad '747 patent were unpatentable over the Kinugasa '024 patent and the Twigg '647 application.

JA0052-53. The following chart sets forth a side-by-side comparison of two independent claims of the Bandl-Konrad '747 patent. On the left is claim 1 of the Bandl-Konrad '747 patent, which the PTAB held not to be unpatentable, and on the right is claim 9 of the Bandl-Konrad '747 patent, which the PTAB held to be unpatentable.

Claim 1 of the Bandl-Konrad '747 Patent – Held Patentable by PTAB	Claim 9 of the Bandl-Konrad '747 Patent – Held Unpatentable by PTAB
An installation for aftertreatment of exhaust gas generated by a diesel engine of a motor vehicle, said installation comprising:	An exhaust gas aftertreatment method for purifying an exhaust gas of a diesel engine of a motor vehicle, said method comprising:
a nitrogen oxide storage catalytic converter configured for temporarily storing nitrogen oxides contained in the exhaust gas during adsorption operating phases with a lean exhaust gas air ratio and, releasing and reducing stored nitrogen oxides during regeneration operating phases with a rich exhaust gas air ratio;	temporarily storing nitrogen oxides contained in the exhaust in a nitrogen oxide storage catalytic converter during adsorption operating phases;
an SCR catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter, said SCR catalytic converter being configured to receive and store ammonia generated by the nitrogen oxide storage catalytic converter, and to reduce nitrogen oxides in the exhaust gas with the stored ammonia;	releasing stored nitrogen oxides from the nitrogen oxide storage catalytic converter during regeneration operation phases, and thereby generating ammonia;
	temporarily storing generated ammonia in an SCR catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter;
	using the stored for nitrogen oxide reduction in the SCR catalytic converter;
	operating the combustion device under lean-burn conditions of the engine during adsorption operating phases;

a particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter; and	
an oxidation catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas.	during lean-burn conditions of the engine oxidizing carbon monoxide and hydrocarbons contained in the exhaust gas in an oxidizing catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas; and
	operating the combustion device under rich-burn conditions during regeneration operating phases.

JA0102-103, claims 1 and 9 (emphasis added).

As is illustrated by the above table, the only material difference between claims 1 and 9 is the limitation providing for “a particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter” (indicated in bold text in the above table). JA0102-103, claims 1 and 9. Further, the PTAB found that using a particulate filter in an exhaust gas system with an LNT and SCR catalyst was obvious. JA0054-55. Specifically, when considering the obviousness of the claims of the Gandhi ‘585 application, the PTAB stated that “modifying Kinugasa ‘024 with the well-known ‘filtering’ technique as disclosed, for example, by Twigg ‘647 to filter the particulate filter (without more) would involve nothing more than an obvious combination of prior art elements according to known methods to yield predictable results.” JA0054-55.

Despite these findings and the absence of any evidence of unexpected results, the PTAB erroneously concluded that the specific arrangement of the particulate filter supported a finding of patentability. JA0055. This minor difference between the prior art and the claimed invention, however, does not as a matter of law support a finding of patentability. *See KSR*, 550 U.S. at 418. Rather, as set forth in *KSR*, “the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art.” *KSR*, 550 U.S. at 406 (*quoting* 35 U.S.C. § 103(a)).

At the time of the claimed invention, the potential locations for a particulate filter were finite and predictable. Namely, the prior art would have directed a person of ordinary skill in the art to include a particulate filter in a system comprising an LNT and an SCR catalyst in the following three locations: (1) upstream of the LNT and SCR catalyst; (2) downstream of the LNT and SCR catalyst; or (3) upstream of the LNT catalyst and downstream of the SCR catalyst. Thus, because there were “a finite number of identified, predictable solutions” for the location of the particulate filter, this feature cannot impart patentability to the claimed invention. *See KSR*, 550 U.S. at 421. This case is similar to both *Bayer Schering Pharma AG v. Barr Laboratories, Inc.*, 575 F.3d 1341, 1350 (Fed. Cir. 2009) and *Perfect Web Technologies, Inc. v. InfoUSA, Inc.*, 587 F.3d 1324, 1331

(Fed. Cir. 2009), in which this Court determined that when the prior art directed a person of ordinary skill in the art to two or three predictable solutions, the claimed invention would have been obvious. Here, the prior art would have directed one of ordinary skill in the art to three predictable solutions. Therefore, the PTAB erred and independent claim 1 is unpatentable over the prior art.

Furthermore, the PTAB erred in finding dependent claims 2-8, 9, 11-15 and 18 patentable over the prior art. In determining these dependent claims non-obvious, the PTAB relied on the disclosure of three features in these claims:

- (1) a “particulate filter” arranged in a specific order, i.e., “*upstream* of the SCR catalytic converter and *downstream* of the nitrogen oxide catalytic converter,” as recited in Bandl-Konrad Claims 1-8 and 19
- (2) “filtering out particulates in the exhaust gas with a particulate filter arranged downstream of the nitrogen oxide storage catalytic converter and guiding filtered exhaust gas to the SCR catalytic converter” as recited in Bandl-Konrad Claims 10, 16, and 17; and
- (3) “hydrogen sulfide formed during the desulfation phases is oxidized by the SCR catalytic converter” as recited in Bandl-Konrad Claim 15.”

JA0053. As discussed above, the first two features would have been obvious in view of the prior art. Furthermore, the third feature would have been obvious in view of the prior art. In its opinion, the PTAB determined that “Claim 15 is

unpatentable over Gandhi ‘470 application, Khair ‘096 and Pieplu Article.”²

Therefore, the additional subject matter of claim 15 cannot impart patentability to the claims of the Bandl-Konrad ‘747 patent. In view of the above, the PTAB erred in holding that Junior Party Bandl-Konrad overcame the presumption set forth in 37 C.F.R. 413.207(c) that claims 1-8, 9, 11-15 and 18 were patentable over the prior art.

C. The PTAB Erroneously Held that Senior Party Gandhi Failed To Prove that Claims 1-8, 10, 16-17 and 19 Were Unpatentable Over the Gandhi ‘470 Application and the Khair ‘096 Patent

Not only did the PTAB err in holding that claims 1-8, 10, 16-17 and 19 were patentable over the Kinugasa ‘024 patent and the Twigg ‘647 application, but the PTAB further erred in holding these claims to be patentable over the Gandhi ‘470 application and the Khair ‘096 patent. During the interference, Senior Party Gandhi asserted that the claims of the Bandl-Konrad ‘747 patent were obvious over the Gandhi ‘470 application (a grandparent of the Gandhi ‘558 application),

² Page 70 of the Opinion contains a typographical error. The Opinion gives credibility to Gandhi’s obviousness argument with respect to this claim and notes that “Bandl-Konrad has not offered any rebuttal.” The Opinion, however, further notes that “Therefore, in the absence of Bandl-Konrad’s opposition, we agree with Gandhi and hold that Gandhi has *not* shown that Claim 15 is unpatentable under 35 U.S.C. § 103(a) over Gandhi ‘470 application, Kaneko ‘883 and Pieplu Article.” JA0070 (emphasis added). In the context of this sentence and the PTAB’s decision, it is clear that the inclusion of the word “not” was a typographical error. On the next page of the opinion the PTAB held that this claim is unpatentable over the prior art. JA0071.

the Khair '096 patent and the knowledge of a person of ordinary skill in the art.

JA0056-57. The PTAB failed to find that these claims were unpatentable, again on the erroneous basis that the prior art did not teach the location of a particulate filter upstream of an SCR catalyst and downstream of an LNT. JA0068-69.

As with its consideration of the Kinugasa '024 patent and the Twigg '647 application, the PTAB acknowledged that the location of the particulate filter was the crux of the obviousness analysis in considering Senior Party Gandhi's unpatentability arguments. JA0067 ("The dispositive question is whether it would have been obvious for a person skilled in the art to arrange a particulate filter upstream of the NH₃-SCR washcoat and downstream of the lean NO_x trap (LNT) washcoat, shown in Figs. 7a-7c of Gandhi '470 application."). And just as it did in its analysis of the Kinugasa '024 patent and the Twigg '647 application, the PTAB erroneously held that the location of the particulate filter provided grounds for the patentability of claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad '747 patent. JA0071.

The Gandhi '470 application, like the claims of the Bandl-Konrad '747 patent that were held unpatentable, discloses an exhaust gas system comprising an LNT, an SCR catalyst, and an oxidation catalytic converter arranged as a first exhaust gas aftertreatment component. JA1203-218. The Gandhi '470 application, however, does not disclose a particulate filter. Rather, the Khair '096 patent

discloses this feature. *See, e.g.*, JA1220, Figure 1. Further, it would have been obvious to a person of ordinary skill in the art to place a particulate filter between the LNT and SCR catalyst taught in Gandhi in view of the Khair ‘096 Patent. JA1152-54 at ¶¶ 27-30.

The Khair ‘096 Patent discloses a system for purifying exhaust gas having a particulate filter located downstream of an LNT. The Khair ‘096 patent notes that this arrangement advantageously combines the features of a particulate filter and an LNT. JA1223, col. 4, ll. 4-10. Thus, one of ordinary skill in the art would have been motivated based on the Khair ‘096 patent to add a particulate filter to the system disclosed in the Gandhi ‘470 application. JA1153-54 at ¶ 29. That would have resulted in placing the particulate filter downstream of the LNT of Gandhi while placing an oxidation catalyst upstream. JA1152-53 at ¶ 29; JA1165-66 at ¶ 65. The addition of the oxidation catalyst and the particulate filter in this manner would have merely been the addition of known catalytic elements for purposes of performing their known intended function of mitigating particulate and NO_x emissions. JA1153-54 at ¶ 29.

1. The Obviousness of Claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad ‘747 Patent is Supported by The Entirety of the Evidence

The legal conclusion of obviousness of claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad ‘747 patent is supported by the entirety of the evidence. The PTAB

erroneously stated that Senior Party Gandhi relied solely on its expert's testimony for the obviousness of the location of the particulate filter. JA0065. Rather, the Khair '096 patent itself would have motivated one of ordinary skill in the art to arrive at the invention set forth in the claims of the Bandl-Konrad '747 patent. JA1219-1226. Specifically, the Khair '096 patent teaches that the removal of NO_x using a particulate filter is limited by the amount of carbon present in the filter. JA1224 at col. 6, ll. 3-15. While this disclosure is made in the discussion of a second embodiment having the filter upstream of the LNT, one of ordinary skill in the art based on the entirety of the disclosure of the Khair '096 patent would have recognized that the same problem – having unreacted NO_x pass through the filter – exists where the filter is downstream of the LNT. JA1224 at col. 6, ll. 3-15.

Furthermore, a person of ordinary skill in the art would have arrived at the invention set forth in claims 1-8, 10, 16-17 and 19 for reasons independent from the motivation articulated in the testimony of Dr. Harold, Senior Party Gandhi's expert. Namely, a person of ordinary skill in the art would have recognized that combining a particulate filter, as described in the Khair '096 patent with the exhaust gas purification system disclosed in the Gandhi '470 application would have presented only a small, finite number of options as to location of the particulate filter. The PTAB determined that the Gandhi '470 application discloses an LNT upstream of an SCR catalyst. JA0058.

In view of the limited number of options for placement of the particulate filter and the absence of any evidence of unexpected results, it would have been obvious to one of ordinary skill in the art based on the teachings of the Gandhi '470 application to place a particulate filter upstream of the SCR catalyst and downstream of the LNT to further remove NO_x from the exhaust gas using reductant stored in the SCR catalyst as set forth in the Khair '096 patent. JA1224 at col. 6, ll. 3-15. Thus, the totality of the evidence supports a conclusion that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad '747 patent would have been obvious over the teachings of the Gandhi '470 application and the Khair '096 patent.

2. The Prior Art Does Not Teach Away from the Location of a Particulate Filter Upstream from an LNT and Downstream from an SCR Catalyst

In determining that claims 1-8, 10, 16-17 and 19 were patentable, the PTAB erroneously failed to consider the entirety of the teachings of the Gandhi '470 application. The PTAB erroneously determined that the Gandhi '470 application would have discouraged one of ordinary skill in the art from incorporating a particulate filter between an LNT and an SCR catalyst. JA0069-70. In reaching this conclusion, the PTAB erroneously relied on statements directed to a single embodiment disclosed in the Gandhi '470 application. JA0069-70.

The PTAB failed to follow this Court's precedent and therefore erred as a matter of law in finding that the Gandhi '470 application taught away from the claimed invention. Specifically, the PTAB determined that the mere disclosure of alternative designs in the Gandhi '470 application taught away from the claimed invention. JA0069-70. This Court has cautioned against just such a finding. *See In re Mouttet*, 686 F.3d 1322, 1333-34 (Fed. Cir. 2012) ("Thus, the 'mere disclosure of alternative designs does not teach away.' This court has further explained that just because better alternatives exist in the prior art does not mean that an inferior combination is inapt for obviousness purposes.") (internal citations omitted).

In reaching its conclusion regarding teaching away, the PTAB relied on testimony by Dr. Kröcher, Junior Party Bandl-Konrad's expert, directed to a single example of the Gandhi '470 application. JA0069-70. Based on this testimony, the PTAB concluded that the "Gandhi '470 application contains numerous disclosures that would have discouraged one skilled in the art from incorporating a filter between the disclosed lean NO_x trap and NH₃-SCR catalytic converter shown in Figs. 4a-4c." JA0069 (emphasis added); *see also* JA0070 ("We are persuaded by Dr. Kröcher's testimony that Gandhi '470 application contains disclosures that would have discouraged one skilled in the art from incorporating a filter between

the disclosed lean NO_x trap and NH₃-SCR catalytic converter shown in Figs. 4a-4c.") (emphasis added).

The statements of the Gandhi '470 application on which the PTAB relied are directed to "desirable" alternatives. JA0069-70. Such teachings directed to optimal or preferred embodiments are not relevant to an inquiry of teaching away. *See Galderma*, 737 F.3d at 739 ("A teaching that a composition may be optimal or standard does not criticize, discredit or otherwise discourage investigation into other compositions."). Thus, the PTAB erred in relying on these statements in the Gandhi '470 application.

Even if the disclosure of the Gandhi '470 application would have discouraged a person of ordinary skill in the art from the incorporation of a filter between the LNT and the SCR catalyst in the embodiment illustrated in Figures 4a-4c (which Senior Party Gandhi does not believe to be the case), this evidence would be insufficient to conclude that the Gandhi '470 application teaches away from the claimed invention. Consistent with this Court's repeated holdings, the teachings directed to a single embodiment of the Gandhi '470 application cannot teach away from the claimed invention. *See In re Mouttet*, 686 F.3d at 1333-34; *In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004). Nothing in Gandhi criticizes or discourages the use of an arrangement in which a particulate filter is located between the LNT and the SCR catalyst. JA1203-218. The fact that in some of

Gandhi's embodiments, such an arrangement would have been less advantageous or impractical, would not have discouraged a person of ordinary skill from using the arrangement in other disclosed embodiments.

Even more, the PTAB erroneously relied on statements directed to preferred embodiments in the Gandhi '470 application. For example, the PTAB relied on Dr. Kröcher's statement that the Gandhi '470 application suggests that arranging a particulate filter between the LNT and SCR catalyst would have increased the cost of the system. JA0069. While paragraph [0056] of the Gandhi '470 application does suggest that there are benefits to incorporating an LNT and SCR washcoat into a single substrate, those teachings directed to potentially beneficial alternatives do not detract from the teachings of other alternatives in the Gandhi '470 application. *See In re Mouttet*, 686 F.3d at 1333-34 ("This court has further explained that just because better alternatives exist in the prior art does not mean that an inferior combination is inapt for obviousness purposes.").

The Gandhi '470 application discloses several embodiments of LNT-SCR catalyst systems. In some of the embodiments, such as the embodiment in Figure 2, the LNT and SCR catalyst are not incorporated into a single substrate. *See* JA1205, Figure 2. Rather, the LNT and SCR catalyst of Figure 2 are separate components that are not incorporated into a single substrate. *See* JA1205, Figure 2. Therefore, the fact that certain embodiments of the Gandhi '470 application

would not lead one of ordinary skill in the art to arrive at the claimed invention is inapt for the obviousness analysis, and the PTAB erred by considering this evidence as evidence of teaching away.

CONCLUSION

For the reasons discussed above, the PTAB's judgment that claims 1-8, 10, 16-17 and 19 of the Bandl-Konrad '747 patent are not unpatentable must be reversed.

Dated: January 13, 2014

Respectfully submitted,

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ADDENDUM 1

July 26, 2013 Opinion, *Brigitte Bandl-Konrad et al. v. Haren S. Gandhi et al.*,
Patent Interference No. 105,839 (P.T.A.B.)
(Paper No. 125)

JA0001-74

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Paper 125
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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**BRIGITTE BANDL-KONRAD, ANDREAS HERTZERG,
BERND KRUTZSCH, ARNO NOLTE, MARKUS PAULE,
STEFAN RENFFTLEN, NORBERT WALDBUESSER,
MICHEL WEIBEL, GUENTER WENNINGER, and
ROLF WUNSCH**
Junior Party
(Patent No. 7,814,747)

v.

**HAREN S. GANDHI, JOHN VITO CAVATAIO,
ROBERT HENRY HAMMERLE, and
YISUN CHENG**
Senior Party
(Application 12/706,558)

Patent Interference No. 105,839 (HHB)
Technology Center 1700

Before RICHARD E. SCHAFER, RICHARD TORCZON, and HUNG H. BUI,
Administrative Patent Judges.

BUI, *Administrative Patent Judge.*

DECISION ON MOTIONS – 37 CFR §41.125(a)

I. INTRODUCTION

Pending before us are the following non-priority motions:

(1) Bandl-Konrad Motion 1 (Paper 29) seeks to substitute new proposed Count A for the original Count 1.

- Gandhi Opposition 1 (Paper 38)
- Bandl-Konrad Reply 1 (Paper 46)

(2) Bandl-Konrad Motion 2 (Paper 30), which is contingent on Bandl-Konrad Motion 1, seeks to re-designate Claims 1-14 and 16-18 of Bandl-Konrad Patent No. 7,814,747 (Bandl-Konrad '747 patent) and Claims 9-13, 19, 20, 28, 30-35, and 46-49 of Gandhi's involved application Serial No. 12/706,558 (Gandhi's involved application) as corresponding to the substituted Count A.

- Gandhi Opposition 2 (Paper 39)
- Bandl-Konrad Reply 2 (Paper 47)

(3) Bandl-Konrad Motion 3 (Paper 31) seeks entry of judgment against Gandhi based on an alleged lack of a written description.

- Gandhi Opposition 3 (Paper 40)
- Bandl-Konrad Reply 3 (Paper 48)

(4) Bandl-Konrad Motion 4 (Paper 32) seeks entry of judgment against Gandhi based on an alleged lack of patentability under 35 U.S.C. §§ 102 and 103.

- Gandhi Opposition 4 (Paper 41)
- Bandl-Konrad Reply 4 (Paper 49)
- Gandhi Sur-Reply 4 (Paper 51)

(5) Gandhi Substantive Motion 1 (Paper 26) seeks entry of judgment against Bandl-Konrad based on an alleged lack of patentability under 35 U.S.C. §§ 102 and 103.

- Bandl-Konrad Opposition (Paper 37)
- Gandhi Reply (Paper 50)

In Bandl-Konrad Motion 3 (Paper 31), Bandl-Konrad argues that Claims 10-13, 19, 20, 28, 31, 32, 34, 34, and 46-49 of Gandhi's involved application Serial No. 12/706,558 are unpatentable under 35 U.S.C. § 112, first paragraph, for lack of written description support from Gandhi's involved application. However, Bandl-Konrad does not challenge Gandhi's independent Claims 9, 30, and 33.

In Bandl-Konrad Motion 4 (Paper 32), Bandl-Konrad argues:

- Claims 9 and 46 of Gandhi's involved application are unpatentable under 35 U.S.C. §§ 102 and 103 as being anticipated or rendered obvious over Kinugasa, U.S. Patent No. 6,109,024 (Kinugasa '024; Ex. 2004);
- Claims 19, 30, 32, 33 and 35 of Gandhi's involved application are unpatentable under 35 U.S.C. § 102(b) as being anticipated by Kinugasa '024 (Ex. 2004);
- Claims 10, 31, 34 and 47 of Gandhi's involved application are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Kinugasa '024 (Ex. 2004) and Twigg, PCT International Application No. 00/21647 (Twigg '647; Ex. 2013); and
- Claims 48-49 of Gandhi's involved application are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Kinugasa '024 (Ex. 2004).

In Gandhi Substantive Motion 1 (Paper 26), Gandhi argues:

- Claim 9 of Bandl-Konrad '747 patent is unpatentable under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent Application Publication No. 2004/0076565 (Ex. 1005) (now issued as U.S. Patent No. 7,332,135), the grandfather of Gandhi's involved application, (hereinafter referred to as Gandhi '470 application¹);

¹ Gandhi '470 application published on April 22, 2004 with an earlier U.S. filing date of October 22, 2002, and as such, qualifies a prior art under 35 U.S.C. § 102(e) against Bandl-Konrad '747 patent.

- Claims 11-15 and 18 of Bandl-Konrad ‘747 patent are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Gandhi ‘470 application in view of a skilled artisan knowledge as represented by Kolmanvosky, U.S. Patent No. 6,347,512 (‘Kolmanvosky ‘512) (Ex. 1012); Kaneko, U.S. Patent No. 7,127,883 (Kaneko ‘883; Ex. 1013); and Andreasson WO 99/39809 (Andreasson ‘809; Ex. 1008);
- Claims 1, 4, 5, 7 and 10 of Bandl-Konrad ‘747 patent are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Gandhi ‘470 application in view of Khair, U.S. Patent No. 6,293,096 (Khair ‘096; Ex. 1006); and
- Claims 2, 3, 6, 8, 16, 17 and 19 of Bandl-Konrad ‘747 patent are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Gandhi ‘470 application, Khair ‘096 and in view of a skilled artisan knowledge as represented by other prior art references.

We exercise our discretion under 37 C.F.R. § 41.125(a) to take up these motions in the following order (*Berman v. Housey*, 291 F.3d 1345, 1352 (Fed. Cir. 2002); 37 C.F.R. § 41.125(a)):

(1) Bandl-Konrad Motion 3 (Paper 31) to address an alleged lack of “written description” under 35 U.S.C. § 112, first paragraph;

(2) Bandl-Konrad Motion 4 (Paper 32) to account for an alleged lack of patentability of any Gandhi Claims that are fully supported by a written description in the original specification of Gandhi’s involved application and that survive Bandl-Konrad Motion 3 (Paper 31); and

(3) Gandhi Motion 1 (Paper 26) to account for an alleged lack of patentability of Bandl-Konrad Claims 1-19.

Claims 9-13, 19, 20, 28, 30-35 and 46-49 of Gandhi’s Involved Application

As discussed below, the preponderance of the evidence leads us to find that Bandl-Konrad has shown that Gandhi’s Claims 11-13 and 20 as presented in

Bandl-Konrad Motion 3 (Paper 31) are unpatentable under 35 U.S.C. § 112, first paragraph, for lack of written description support from Gandhi's involved application. However, we find that Gandhi's remaining Claims 9, 10, 19, 28, 30-35, and 46-49 (including unchallenged Claims 9, 30, and 33) have not been shown to lack written description support in the original specification of Gandhi's involved application.

Nevertheless, we find that Bandl-Konrad has shown that Gandhi's remaining Claims 9, 10, 19, 28, 30-35, and 46-49 as presented in Bandl-Konrad Motion 4 (Paper 32) are unpatentable under 35 U.S.C. §§ 102 and 103 over prior art, including Kinugasa '024 and Twigg '647. Accordingly, we hold that all of Gandhi Claims 9-13, 19, 20, 28, 30-35, and 46-49 of Gandhi's involved application are unpatentable under 35 U.S.C. §§ 102, 103, and 112, 1st paragraph.

Claims 1-19 of Bandl-Konrad '747 Patent

For the reasons detailed below, we find that Bandl-Konrad has not rebutted the presumption under 37 C.F.R. §41.207(c) regarding Claims 9, 11-14, and 18 of Bandl-Konrad '747 patent. As such, we hold that Claims 9, 11-14, and 18 of Bandl-Konrad '747 patent are unpatentable under 35 U.S.C. §§ 102 and 103 over the same prior art cited in Bandl-Konrad Motion 4 (Paper 32). As a result, we only need to address remaining Claims 1-8, 10, 15-17, and 19 of Bandl-Konrad '747 patent as presented in Gandhi Substantive Motion 1 (Paper 26).

As discussed below, the preponderance of evidence leads us to find that Gandhi has not shown that Claims 1-8, 10, 16-17, and 19 of Bandl-Konrad '747 patent are unpatentable under 35 U.S.C. §§ 102 and 103 over prior art, including Gandhi '470 application and Khair '096. However, Gandhi has shown that Claim 15 of Bandl-Konrad '747 patent is unpatentable over Gandhi '470 application,

Khair '096 and Pieplu Article. Accordingly, we hold that Claims 9, 11-15, and 18 of Bandl-Konrad '747 patent are unpatentable under 35 U.S.C. §§ 102 and 103.

Summary of Decisions on Motions

(1) Bandl-Konrad Motion 3 (Paper 31) is GRANTED as to Gandhi Claims 11-13 and 20, and is otherwise DENIED as to Gandhi Claims 10, 19, 28, 31, 32, 34, 35, and 46-49.

(2) Bandl-Konrad Motion 4 (Paper 32) is GRANTED as to Gandhi's remaining Claims 9-10, 19, 28, 30-35, and 46-49. We need not reach the merits of the motion with respect to Gandhi Claims 11-13 and 20 as these claims were held unpatentable as a result of Bandl-Konrad Motion 3 (Paper 31).

(3) Bandl-Konrad Claims 9, 11-14, and 18 of Bandl-Konrad '747 are unpatentable by operation of the presumption of 37 C.F.R. § 41.207(c). Bandl-Konrad has failed to show that Claims 9, 11-14, and 18 are not unpatentable over the prior art cited against Gandhi Claims 9-10, 19, 28, 30-35, and 46-49 in Bandl-Konrad Motion 4 (Paper 32).

(4) Gandhi Substantive Motion 1 (Paper 26) is GRANTED as to Bandl-Konrad Claim 15 of Bandl-Konrad '747, and is otherwise DENIED as to Bandl-Konrad Claims 1-8, 10, 16, 17 and 19.

As a result of the above decisions, Gandhi has no patentable claims and Bandl-Konrad Claims 1-8, 10, 16, 17 and 19 have not been shown to be unpatentable. Because there currently is no basis for formulating a count representing the common patentable subject matter of the parties, it is appropriate to terminate the interference at this point. Consequently, we need not reach Bandl-Konrad Motion 1 (Paper 29) to substitute new Count and Bandl-Konrad contingent Motion 2 (Paper 30) to re-designate claims corresponding to the

substituted new Count. Therefore, Bandl-Konrad Motion 1 (Paper 29) and Bandl-Konrad contingent Motion 2 (Paper 30) are DISMISSED.

II. BACKGROUND

An administrative patent judge (APJ) declared an interference (Paper 1) between Junior Party Bandl-Konrad's involved patent, U.S. Patent No. 7,814,747² ("Bandl-Konrad '747 patent") and Senior Party Gandhi's involved application, U.S. Serial No. 12/706,558.³

The interfering subject matter is directed to eliminating or reducing polluting nitrogen oxide ("NO_x") produced during engine operation (Ex. 2008, ¶¶18-53; Ex. 2014, ¶¶13-35), and is represented by a single Count 1, which is Bandl-Konrad Claim 9 or Gandhi Claim 19. Bandl-Konrad Claim 9, which is identical to Gandhi Claim 19, is reproduced below:

9. An exhaust gas aftertreatment method for purifying an exhaust gas of a diesel engine of a motor vehicle, said method comprising:

temporarily storing nitrogen oxides contained in the exhaust in a nitrogen oxide storage catalytic converter during adsorption operating phases;

releasing stored nitrogen oxides from the nitrogen oxide storage catalytic converter during regeneration operation phases, and thereby generating ammonia;

temporarily storing generated ammonia in an SCR [selective catalytic reduction] catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter;

using the stored for nitrogen oxide reduction in the SCR catalytic converter;

² Real Party in Interest is Daimler AG.

³ Real Party in Interest is Ford Global Technologies, LLC.

operating the combustion device under lean-burn conditions of the engine during adsorption operating phases;

during lean-burn conditions of the engine oxidizing carbon monoxide and hydrocarbons contained in the exhaust gas in an oxidizing catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas; and

operating the combustion device under rich-burn conditions during regeneration operating phases.

Paper 7, pp. 3-4. Claims 1-19 of Bandl-Konrad '747 patent (Paper 7; Ex. 2001), as well as Claims 9-13, 19-20, 28, 30-35 and 46-49 of Gandhi's involved application (Paper 6; Ex. 2002) which correspond to Count 1.⁴

Bandl-Konrad relies on the expert testimony of Dr. Oliver Kröcher.⁵ Gandhi relies on the expert testimony of Dr. Michael P. Harold.⁶

Dr. Kröcher has been the head of the Catalysis for Energy Group (previously named the Exhaust Gas Aftertreatment Group) and the Bioenergy and Catalysis

⁴ In relation to Count 1, the Board has previously accorded (1) Bandl-Konrad '747 patent benefit to an earlier U.S. Application Serial No. 10/541,311, filed 24 January 2006, now U.S. Patent No. 7,210,288; PCT/EP2003/14313, filed 16 December 2003; and DE 103 00 298.7, filed 2 January 2003; and (2) Gandhi '558 application benefit to earlier parent U.S. Application Serial No. 12/325,787, filed 1 December 2008, now U.S. Patent 7,674,743; U.S. Application Serial No. 11/684,064, filed 9 March 2007, now U.S. Patent No. 7,485,273; and earlier grandparent U.S. Application Serial No. 10/065,470 (Gandhi '470 application) filed 22 October 2002, now U.S. Patent No. 7,332,135.

⁵ See Declaration of Oliver Kröcher, Ph.D., in support of Beckmann Motion 1, Ex. 2003, ¶¶6-10 (Appendix A – Kröcher CV); 2nd Declaration of Oliver Kröcher, Ph.D., in support of Bandl-Konrad Motion 3, Ex. 2009; 3rd Declaration of Oliver Kröcher, Ph.D., in support of Bandl-Konrad Motion 4, Ex. 2014; and 4th Declaration of Oliver Kröcher, Ph.D., in support of Bandl-Konrad Opposition 1, Ex. 2018.

⁶ See Declaration of Michael Harold, Ph.D., in support of Gandhi Substantive Motion 1, Ex. 1001, ¶9; Harold CV, Ex. 1002; 2nd Declaration of Michael Harold, Ph.D., Ex. 1030; and 3rd Declaration of Michael Harold, Ph.D., Ex. 1037.

Laboratory at the Paul Scherrer Institute in Switzerland since 2003 with publications and research experience in the field of exhaust gas aftertreatment systems spanning times relevant to this interference. Dr. Kröcher is well qualified to testify regarding the technology in this interference.

Dr. Harold is a professor at University of Houston with publications and research experience in catalytic science and engineering preceding and spanning times relevant to this interference. Dr. Harold is well qualified to testify regarding the technology in this interference.

III. BANDL-KONRAD MOTION 3 (PAPER 31) SEEKING ENTRY OF JUDGMENT AGAINST GANDHI BASED ON AN ALLEGED LACK OF A WRITTEN DESCRIPTION UNDER 35 U.S.C. § 112, ¶1

In Bandl-Konrad Motion 3 (Paper 31), Bandl-Konrad asserts that Claims 10-13, 19, 20, 28, 31, 32, 34, 35, and 46-49 of Gandhi's involved application, which represent almost all of Gandhi's claims involved in this interference (except for independent Claims 9, 30, and 33)⁷ are unpatentable under 35 U.S.C. § 112, first paragraph, for lack of written description in the original specification of Gandhi's involved application, U.S. Patent Application Serial No. 12/706,558. Claims 11, 19, and 46 are independent claims, and the remainder claims are dependent. Below are our findings of facts, analysis and conclusion of law regarding written description support from Gandhi's involved application for each of the contested Claims 10-13, 19, 20, 28, 31, 32, 34, 35, and 46-49 of Gandhi's involved application.

⁷ Bandl-Konrad has not contested the written description support for Gandhi's Claims 9, 30, and 33. As such, Gandhi's Claims 9, 30, and 33 are presumed to have written description support from the specification of Gandhi's involved application.

A. Findings of Facts

We make the following findings of facts (“FFs”) to resolve issues presented in Bandl-Konrad Motion 3 (Paper 31). These FFs, as well as others made elsewhere in the Opinion, are supported by at least a preponderance of the evidence on the record. *Ethicon, Inc. v. Quigg*, 849 F.2d 1422, 1427 (Fed. Cir. 1988).

1. The terms “nitrogen oxide storage catalytic converter,” “NO_x absorber catalytic converter,” “NO_x trap,” “lean NO_x trap,” “LNT” and “lean NO_x absorber” as used in Gandhi’s involved application, U.S. Patent Application Serial No. 12/706,558 (Gandhi ‘558 application;⁸ Ex. 1025), and its earlier grandparent U.S. Patent Application Serial No. 10/065,470 (Gandhi ‘470 application;⁹ Ex. 1005), as well as Bandl-Konrad’s involved patent (‘747 patent, Ex. 1003) are interchangeable and refer to the same catalytic technology that, among other things, operates in a cyclical fashion storing NO_x during lean conditions (lean mode of operation) and reducing NO_x during rich conditions (rich mode of operation).¹⁰
2. The terms “SCR catalytic converter” and “NH₃-SCR catalyst” as used in Gandhi’s involved application (Gandhi ‘558 application), and its earlier

⁸ Gandhi’s involved application (Gandhi ‘558 application) is relied upon to support Bandl-Konrad Motion 3 (Paper No. 31) to determine whether Gandhi Claims 10-13, 19, 20, 28, 31, 32, 34, 35, and 46-49 are unpatentable under 35 U.S.C. § 112, 1st paragraph.

⁹ In contrast, Gandhi ‘470 application is relied upon to support Gandhi Substantive Motion 1 (Paper 26) to determine whether Bandl-Konrad Claims 1-19 are patentable under 35 U.S.C. §§ 102 and 103.

¹⁰ See Declaration of Oliver Kröcher, Ph.D., in support of Bandl-Konrad Motion 3 (Paper 31), Ex. 2009, ¶25; Declaration of Michael Harold, Ph.D., in support of Gandhi Motion 3 (Paper 31), Ex. 1030, ¶55; Ex. 2014, ¶58.

grandparent, Gandhi '470 application, as well as the Bandl-Konrad's involved patent ('747 patent, Ex. 1003) are interchangeable and refer to the same technology.¹¹

3. The terms "lean exhaust gas air ratio," "lean-burn conditions," "lean cycles" and "lean conditions" refer to the same operating conditions.¹²
4. Likewise, the terms "rich exhaust gas air ratio," "rich-burn conditions," "rich cycles" and "rich conditions" refer to the same operating conditions.¹³
5. The term "oxidation catalytic converter" contained in Gandhi's Claim 11 and "oxidizing catalytic converter" contained in Gandhi's Claim 19 are interchangeable.
6. A "three-way" catalytic converter is an oxidizing or oxidation catalytic converter. Ex. 1017, col. 1, ll. 40-43.

Gandhi's Involved Application (Gandhi '558 Application)

7. Gandhi '588 application discloses a catalyst system, as shown in Fig. 2, capable of simultaneously eliminating ammonia emissions and improving net NO_x conversion. Ex. 1025; Gandhi '558 application, ¶[0033]. Fig. 2 is reproduced below.

¹¹ See Declaration of Michael Harold, Ph.D., in support of Gandhi Substantive Motion 1 (Paper 26), Ex. 1030, ¶56; Ex. 2014, ¶70.

¹² *Id.*, ¶57.

¹³ *Id.*, ¶58.

As shown in Fig. 2, the catalyst system includes a lean NO_x trap and an NH₃-SCR catalyst. As expressly described by Gandhi ‘558 application:

“The advantage of the catalyst system of this invention is the *use of a combination of a lean NO_x trap and an NH₃-SCR catalyst*. The use of a lean NO_x trap in the present system allows for much greater storage of NO_x, because the NO_x breakthrough that would otherwise happen can be controlled by the NH₃-SCR catalyst. Additionally, the use of a lean NO_x trap as part of this system allows for the operation of the engine at lean conditions for a longer time, and thus provides improved fuel economy Thus the combination of a lean NO_x trap and NH₃-SCR catalyst allows for significant NO_x storage and ammonia production and thus increases net NO_x conversion.”

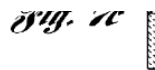
Ex. 1025; Gandhi ‘558 application, ¶[0045] (emphasis added).

8. In a preferred embodiment of Gandhi ‘558 application, the combination of a lean NO_x trap and an NH₃-SCR catalyst (shown in Fig. 2) is implemented as adjacent or alternating lean NO_x trap and NH₃-SCR catalyst zones arranged on a single substrate or a single catalytic converter can, as shown in Figs. 4a-4c (reproduced below).



Ex. 1025; Gandhi '558 application, ¶¶[0046]-[0048]; Figs. 4a-4c.

9. In another preferred embodiment of Gandhi's involved application, the combination of a lean NO_x trap and an NH₃-SCR catalyst (as shown in Fig. 2) is implemented as a lean NO_x trap washcoat and an NH₃-SCR washcoat applied to a single substrate, as shown in Figs. 7a-7c (reproduced below).



As shown in Figs. 7a-7b, the lean NO_x trap washcoat and NH₃-SCR washcoat are formed on the bottom and top layer of a substrate, respectively. In contrast, Fig. 7c involves the use of a one layer washcoat containing both lean NO_x trap and NH₃-SCR washcoat formulations. Ex. 1025; Gandhi '558 application, ¶¶[0052]-[0053]; Figs. 7a-7c.

10. In the context of the washcoat arrangement shown in Figs. 7a-7c, Gandhi ‘558 application also describes that:

“The invention also contemplates engineering such combinations within the pores of the monolithic substrate. *An example of this is incorporating washcoat into porous substrates used for filtering diesel particulate matter.* Thus, this lean NO_x trap/NH₃-SCR catalyst concept can be integrated into diesel particulate matter devices.”

Ex. 1025; Gandhi ‘558 application, ¶[0054] (emphasis added).

11. In an alternative embodiment of Gandhi ‘558 application, “three-way” catalysts are also utilized to improve net NO_x conversion, eliminate NH₃ emissions and reduce catalyst costs, shown in Fig. 9 (reproduced below).

12 

12. The three-way catalytic converter can be located upstream of the NO_x/NH₃-SCR system. Ex. 1025; Gandhi ‘558 application, ¶[0038].

13. As shown in Fig. 9, a first three-way catalyst 14 is positioned in close proximity to the engine 12 to reduce cold start emissions; a second three-way catalyst 16 is modified to enhance the ability of the second three-way catalyst 16 to generate NH₃ emissions; and an NH₃-SCR catalyst 18 is arranged downstream of the second three-way catalyst 16 to store NH₃ produced for reaction with NO_x emissions in order to reduce both NO_x and NH₃ emissions. In other words, a three-way catalyst 14 can be

disposed upstream of a lean NO_x trap/NH₃-SCR system. Ex. 1025;
Gandhi '558 application, ¶[0061].

14. In view of FFs. 6 and 11-13, Gandhi describes an oxidation catalytic
converter as the first exhaust gas aftertreatment component and therefore
discloses an oxidizing catalytic converter as the first exhaust gas
aftertreatment component.

Bandl-Konrad '747 Patent

15. Bandl-Konrad '747 patent discloses an exhaust gas aftertreatment
installation and associated exhaust gas aftertreatment (purification)
method of an exhaust gas generated by an internal combustion engine
using a nitrogen oxide storage catalytic converter (also known as NO_x
storage catalytic converter or NO_x absorber catalytic converter ("NSC"))
and an SCR catalytic converter with the ability to store ammonia. Ex.
2001; Bandl-Konrad '747 patent, col. 1, ll. 16-35.

16. In order to increase the efficiency of the SCR catalytic converter, Bandl-
Konrad '747 discloses a NO₂ producing catalytic converter arranged
upstream of the SCR catalytic converter. Ex. 2001; Bandl-Konrad '474
patent, col. 5, ll. 25-27.

17. In addition, a particulate filter is arranged upstream of the SCR catalytic
converter and downstream of the NO₂ producing catalytic converter to
retain the particulates emitted. Ex. 2001; Bandl-Konrad '474 patent, col.
3, ll. 31-34; col. 4, ll. 59-64; col. 6, ll. 10-21.

18. A further oxidation catalytic converter can also be connected upstream of
the NO_x storage catalytic converter, i.e., positioned as a first exhaust gas
purification component relative to an engine, in order to lower the
emissions of hydrocarbons (HC) and carbon monoxide (CO) during cold

starts. Ex. 2001; Bandl-Konrad ‘747 patent, col. 16, ll. 14-18; col. 9, ll. 5-8.

19. According to Bandl-Konrad ‘747 patent,

“Various possible implementations are possible for the order in which the NO_x storage catalytic converter, SCR catalytic converter, particulate filter and NO₂-producing catalytic converter are arranged in the exhaust train, *each of these implementations having specific properties and advantages*; the options include multi-flow arrangements.”

Ex. 2001; Bandl-Konrad ‘747 patent, col. 7, ll. 41-46 (emphasis added).

20. Bandl-Konrad ‘747 patent describes that:

“Fig. 4 shows a further variant, in which the exhaust gas aftertreatment installation has *a combined SCR and nitrogen oxide storage catalytic converter 15 ...*”

Ex. 2001; Bandl-Konrad ‘747 patent, col. 17, ll. 25-27 (emphasis added).

In other words, a combined nitrogen oxide storage and SCR catalytic converter 15 performs the functions of the NO_x storage catalytic converter 6 and the SCR catalytic converter 7, as described in connection with Figs. 1-3 of Bandl-Konrad ‘747 patent.

21. Bandl-Konrad ‘747 patent further describes that:

“Instead of being arranged upstream of the particulate filter 5, *the NO₂-producing catalytic converter 13 may also be integrated at the outlet end of the NO_x storage catalytic converter 6....* As a further possible option, it is also possible for the *NO₂-producing catalytic converter 13 to be integrated at the inlet end of the SCR catalytic converter 7.* Alternatively, the NO₂ producing catalytic converter 13 can also be dispensed with altogether.”

Ex. 2001; Bandl-Konrad ‘747, col. 16, ll. 4-13 (emphasis added). In other words, the separate NO₂-producing catalytic converter 13, as shown

in Fig. 2, can be integrated at the outlet end or the inlet end of the SCR catalytic converter 7. This way the SCR catalytic converter 7 can also perform the function of the NO₂-producing catalytic converter 13.

22. In addition, Bandl-Konrad '747 patent also describes that:

5 *"If appropriate, the SCR catalytic converter as a separate component can also be dispensed with altogether. In this case, the temperature sensor 8 illustrated in FIG. 2 between particulate filter and SCR catalytic converter can be dispensed with, but the*
 10 *pressure sensor 14 illustrated downstream of the particulate filter is retained."*

Ex. 2001; Bandl-Konrad '747 patent, col. 15, l. 64 – col. 16, l. 3 (emphasis added).

15 23. Bandl-Konrad '747 patent also describes that:

"If appropriate, it is also possible for the separate NO_x storage catalytic converter 6 to be dispensed with altogether, i.e. for its function to be integrated in the particulate filter 5. In this case, it is also possible for
 20 *both the NO₂-producing catalytic converter 13 and the device 11 for supplying reducing agent downstream of the engine and upstream of the NO₂-producing catalytic converter 13 to be dispensed with."*

25 Ex. 2001; Bandl-Konrad '747 patent, col. 15, ll. 49-56 (emphasis added). In other words, the separate NO_x storage catalytic converter 6, as shown in Fig. 2, can be integrated in the particulate filter 5. This way the particulate filter 5 can also perform the function of the NO_x storage catalytic converter 6.

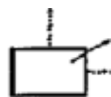
30 24. Fig. 2 of Bandl-Konrad '747 patent, which we reproduce below, discloses exhaust gas aftertreatment components connected in series and arranged in a particular order, such as: (1) a nitrogen oxide (NO_x) storage

catalytic converter 6, (2) a particulate filter 5, (3) an SCR catalytic converter 7, and (4) an oxidation catalytic converter 4.



Ex. 2001; Bandl-Konrad '747 patent, col. 14, ll. 22-31; Fig. 2.

5 25. Fig. 6 of Bandl-Konrad '747 patent (annotated and reproduced below) discloses an embodiment shown in Fig. 2, but with an oxidation catalytic converter arranged as a first exhaust aftertreatment component, as seen in the direction of flow of the exhaust gas.



10 Ex. 2001; Bandl-Konrad '747 patent, col. 16, ll. 14-18; Fig. 6 (annotated).

26. According to Bandl-Konrad '747 patent, certain components shown in connection with Figs. 2 and 6 (as well as other figures), including

temperature sensors 8, NO_x sensors 9, pressure sensors 14, device 11 for supplying reducing agent downstream of an engine, and device 12 for supplying air and pressure sensors 14, can be combined or integrated in order to reduce the overall space taken up.

27. In view of FFs. 19-26, Bandl-Konrad ‘747 patent describes both (1) separate and distinct and (2) integrated components as alternatives.

B. Analysis.

1.

As an initial matter, we reject Bandl-Konrad’s approach to challenging Gandhi’s claims on written description grounds. Bandl-Konrad argues that “for Gandhi to be entitled to the benefit of the October 22, 2002, filing date of [Gandhi Application 10/065,470], Gandhi must show that the specification for the Gandhi ‘470 application (Ex. 2008) discloses the claimed subject matter in Gandhi’s involved application.” Paper 31, p. 2, ll. 15-18. However, the only appropriate specification for the determination of adequate written descriptive support is the specification in which the involved claims form a part, Application 12/706,558. See *Reiffin v. Microsoft Corp.*, 214 F.3d 1342, 1346 (Fed. Cir. 2000). However, because Gandhi ‘558 application is said to be a continuation of Application 12/325,787 which is said to be a continuation of Gandhi ‘470 application, we will presume that the written description of Gandhi’s involved application is identical to that of Gandhi ‘470 application. References in the party’s papers and in testimony referring to Gandhi ‘470 application are considered to be references to Gandhi’s involved application. The citations and references to Gandhi’s application, specification, written description or claims in this opinion are references to those as filed on February 16, 2010.

Second, Bandl-Konrad characterizes that only Claims 11-13, 19, 20, and 28 of Gandhi's involved application were copied from Bandl-Konrad '747 patent, and thus, only Gandhi Claims 11-13, 19, 20, and 28 must be interpreted in the context of the specification of Bandl-Konrad '747 patent for purposes of determining compliance with the written description requirement of 35 U.S.C. § 112, first paragraph.¹⁴ *Agilent Tech., Inc. v. Affymetrics, Inc.*, 567 F.3d 1366, 1375 (Fed. Cir. 2009) (“[W]hen a party challenges a written description for the interference count or the copied claim in an interference, the originating disclosure provides the meaning of the pertinent claim language”). Paper 48, p. 2, ll. 7-10. However, Bandl-Konrad's characterization is incorrect and inconsistent with the prosecution history of Gandhi's involved application. In particular, in an Amendment filed February 14, 2011 filed in Serial No. 12/706,558, Gandhi Claim 19 was copied from Bandl-Konrad '747 patent and is identical to Claim 9 of Bandl-Konrad '747 patent. However, all Gandhi remaining Claims 9-13, 20, 28, 30-35 and 46-49 were said to be substantially copied from Bandl-Konrad '747 patent and are similar, albeit different in scope than Claim 9 of Bandl-Konrad '747 patent. See Amendment, p. 12. We are aware of no reason that would justify treating identically copied and substantially copied claims differently. As such, and for purposes of *Agilent*, all Gandhi “copied” claims, *i.e.*, Claims 9-13, 19-20, 28, 30-35 and 46-49 shall be treated as “copied” claims, and shall be interpreted in the context of Bandl-Konrad's disclosure as discussed herein below.

2.

In order to satisfy the written description requirement under 35 U.S.C. § 112, first paragraph, the specification must convey with reasonable clarity to those

¹⁴ See Gandhi's Request for Interference filed August 1, 2011 and Amendment filed February 14, 2011.

of ordinary skill in the art that as of the filing date of the application the inventor disclosed the claimed invention. *Vas-Cath Inc. v. Mahurkar*, 935 F.2d 1555, 1563-64 (Fed. Cir. 1991); *see also Pandrol USA, LP v. Airboss Ry. Products, Inc.*, 424 F.3d 1161, 1165 (Fed. Cir. 2005). The purpose of the written description requirement is to prevent applicants from later asserting that they invented that which they did not. *Amgen Inc. v. Hoechst Marion Roussel Inc.*, 314 F.3d 1313 (Fed. Cir. 2003). However, the description does not have to be in the exact same words, *in ipsius verbis*, as the language at issue in the corresponding claim. *In re Wertheim*, 541 F.2d 257, 265 (CCPA 1976); *In re Lukach*, 442 F.2d 967, 969 (CCPA 1971). Equally true is that obviousness is not the test for written description. In other words, a description that simply renders obvious a claimed invention is not sufficient to satisfy the written description requirement. *Lockwood v. American Airlines Inc.*, 107 F.3d 1565 (Fed. Cir. 1997). The question is whether the written description objectively tells the person of ordinary skill that the inventor contemplated the subject matter now claimed.

The status quo of an interference is presumed correct. A party wishing to change the status quo may be authorized to file a substantive motion under 37 C.F.R. §41.212(a) to effect that change. As the moving party, Bandl-Konrad bears the burden of proof to demonstrate entitlement to the relief requested. 37 C.F.R. § 41.121(b). To be sufficient, a motion must provide a showing, supported with appropriate evidence, such that, if unrebutted, it would justify the relief sought. 37 C.F.R. § 41.208(b). The applicable standard of proof is by a preponderance of the evidence. *Bosies v. Benedict*, 27 F.3d 539, 541-42 (Fed. Cir. 1994).

3.

Bandl-Konrad has identified four limitations of Gandhi's Claims 10-13, 19, 20, 28, 31-35, and 46-49 said not to be described by Gandhi's written description:

(1) separate and distinct exhaust gas aftertreatment components; (2) an oxidation catalytic converter as the first exhaust gas after treatment component; (3) increasing the amount of NO₂ in the exhaust gas using a catalytic converter upstream of the SCR catalytic converter; and (4) a particulate filter located after the nitrogen oxide storage catalytic converter and before the SCR catalytic converter. Paper 31, pp. 6-14.

1) Separate and Distinct Exhaust Gas Aftertreatment Components

Claims 10-13, 19, 20, 28, 31-35, and 46-49

In Bandl-Konrad Motion 3 (Paper 31), Bandl-Konrad, relying on testimony of its expert, Dr. Oliver Kröcher, asserts that the four specified exhaust gas purification (aftertreatment) components of the parties' claims should be construed as separate and distinct components that exclude integrated or combined components. Paper 31, page 6; Ex. 2009, ¶57.

Citing *Agilent*, 567 F.3d at 1376, Bandl-Konrad argues that Gandhi's Claims 10-13, 19, 20, 28, 31-35, and 46-49 (all but Claims 9, 30 and 33 of Gandhi's involved application) were copied from Bandl-Konrad's patent and therefore must be construed in light of Bandl-Konrad's written description. When read in light of Bandl-Konrad's disclosure, Bandl-Konrad contends that its written description compels a construction that excludes combined or integrated components.

We disagree. Pending claims in interference proceedings are given their broadest reasonable construction in a manner consistent with *Agilent*, i.e., in light of Bandl-Konrad's disclosure. Claim terms are also accorded their ordinary and accustomed meaning as would be understood by one of ordinary skill in the art. *Phillips v. AWH Corp.*, 415 F.3d 1303, 1323 (Fed. Cir. 2005) (*en banc*). In some cases, as here, the ordinary meaning of claim language as understood by a person of skill in the art may be readily apparent even to lay judges, and claim

construction in such cases involves little more than the application of the widely accepted meaning of commonly understood words. *Phillips v. AWH Corp.*, 415 F.3d at 1314. This means that the words of the claims are given their plain meaning unless that meaning is inconsistent with the specification. *In re Zletz*, 893 F.2d 319, 321 (Fed. Cir. 1989). Consequently, care must be exercised as there is an important distinction between interpreting claims in light of the specification and reading limitations into the claims from the specification. *Comark Commc'ns, Inc. v. Harris Corp.*, 156 F.3d 1182, 1186 (Fed. Cir. 1998). Limitations appearing in the specification but not recited in the claim must not be read into the claim. *E-Pass Techs., Inc. v. 3Com Corp.*, 343 F.3d 1364, 1369 (Fed. Cir. 2003) (claims must be interpreted “in view of the specification” without importing limitations from the specification into the claims unnecessarily.)

At the outset, we note that there is no language in any of the Gandhi claims that expressly requires the components to be separate and distinct from each other. The plain language of Gandhi claims simply does not require the four exhaust gas aftertreatment components be “separate” or “distinct” from each other; rather, Gandhi claims simply require various components arranged in a specific order in relation to each other and the exhaust gas flow.

This plain interpretation of Gandhi claims is consistent with Bandl-Konrad’s disclosure, since Bandl-Konrad’s disclosure is also not limited to separate and distinct components. In fact, Bandl-Konrad discloses that exhaust gas components can be combined or integrated together. For example, Bandl-Konrad describes that:

“Fig. 4 shows a further variant, in which the exhaust gas aftertreatment installation has *a combined SCR and nitrogen oxide storage catalytic converter* 15 ...”

Ex. 2001; Bandl-Konrad '747, col. 17, ll. 25-27; FFs. 15-20 (emphasis added).

Bandl-Konrad's disclosure further teaches that:

“Instead of being arranged upstream of the particulate filter 5, the *NO₂-producing catalytic converter 13* may also be integrated at the outlet end of the *NO_x storage catalytic converter 6*.... As a further possible option, it is also possible for the *NO₂-producing catalytic converter 13* to be integrated at the inlet end of the *SCR catalytic converter 7*.”

Ex. 2001; Bandl-Konrad '747, col. 16, ll. 4-13; FFs. 20-17 (emphasis added).

Thus, in the absence of express limiting claim language, there is no basis to construe Bandl-Konrad's invention as excluding integrated components.

Accordingly, Bandl-Konrad's written description does not support construing

Gandhi's copied claims as excluding integrated or combined components.

Even assuming *arguendo* that Bandl-Konrad's claims are limited to separate and distinct components, Bandl-Konrad has failed to establish that Gandhi's written description does not support separate and distinct components.

Bandl-Konrad relies on the testimony of Dr. Kröcher to establish that Gandhi's written description should be construed as only describing integrated or combined components. In particular, Dr. Kröcher proffers two reasons why one skilled in the art would consider Gandhi's written description to exclude combined or integrated components: (1) the claims separately recite four components having a particular relationship with each other, and (2) Gandhi's involved application only discloses integrating filtering particulates with a nitrogen oxide storage catalytic converter and an SCR catalytic converter. Ex. 2009, ¶¶57-58.

We do not consider Dr. Kröcher's testimony to be probative on these points. While the claim language requires that the components have a certain physical relationship to each other, neither the Bandl-Konrad's motion nor Dr. Kröcher's

testimony adequately explains why the claim language excludes combined or integrated components. As previously noted, the claim language itself is totally silent on whether the components are combined, or alternatively, are separate and distinct. All the claim language expressly requires is that the exhaust gases flow
 5 through the components in a required order.

Dr. Kröcher has not explained why the structures disclosed, for example, in Gandhi's Figures 2, 4a and 9, and their accompanying textual descriptions, do not convey to a person skilled in the art the use of separate and distinct components. Each of Gandhi's Figures 2, 4a and 9 shows components which appear to be
 10 separate and distinct from the others. For example, Fig. 4a shows a lean NO_x trap (LNT) as separate and distinct from an SCR catalyst. Ex. 2002, Figs. 2, 4a and 9; FFs. 7-14. Each of these components separately and distinctly performs its designed functions.

Dr. Kröcher's second point is directed to Gandhi's disclosure of a combined
 15 particulate filter, nitrogen oxide storage catalytic converter and SCR catalytic converter. We simply do not see, and Dr. Kröcher has not adequately explained, how Gandhi's discussion of this optional feature (Ex. 1005, ¶¶[0052]-[0053]) conveys that Gandhi teaches that all the other components would be understood only to be integrated or combined components.

For these reasons, Bandl-Konrad has not met its burden of establishing that
 20 its written description and claims are limited to describing "separate" and "distinct" components or that Gandhi's written description is limited to combined or integrated components.

2) *An Oxidation Catalytic Converter as the First Exhaust Gas Aftertreatment*

Claims 11, 19, and 46

Claims 11 and 19 further recite “an oxidation catalytic converter arranged as a **first** exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas.” Ex. 2002, Claims 11 and 19. Gandhi Claim 46 is similar to Claims 11 and 19, except that a generic “catalyst capable of oxidizing” is recited instead of “an oxidizing catalytic converter” as recited in Gandhi Claims 11 and 19. Ex. 2002, Claim 46.

Bandl-Konrad relies on Dr. Kröcher’s testimony, and argues that Gandhi does not have a written description of an oxidation catalyst as the first exhaust gas aftertreatment component as seen in the direction of the flow of the exhaust gas:

Dr. Kröcher found no support in Gandhi’s involved application for this particular arrangement of the oxidation catalytic converter. Ex. 2009, ¶ 66. In fact, according to Dr. Kröcher, Gandhi’s involved application leaves open the possibility that other exhaust gas treatment components can be arranged in front of the oxidation catalytic converter. Ex. 2009, ¶ 66.

Paper 31, p. 8, ll. 14-18.

We have reviewed Dr. Kröcher’s testimony and do not consider it to be probative on features of Gandhi Claims 11, 19, and 46.

First, we find Dr. Kröcher’s testimony, that Gandhi’s written description leaves open the possibility that other exhaust gas treatment components can be arranged in front of the oxidation catalytic converter, not to be relevant. The specific question is whether Gandhi’s written description teaches an oxidation catalytic converter as the first exhaust gas aftertreatment. The fact that Gandhi left open, or even expressly disclosed, that other exhaust treatments could also be

the first component, does not establish that the written description does not also disclose an oxidation catalyst to be the first after treatment.

We have reviewed Gandhi's disclosure and have identified a number of portions relevant to the location of the oxidation catalytic converter. In addition to the lean NO_x trap (LNT) and the SCR catalyst converter, Gandhi describes the use of three-way catalysts. A three-way catalyst oxidizes hydrocarbons and carbon monoxide as well as NO_x. Ex. 1005, ¶[0002]; Ex. 1017, col. 1, ll. 40-43; Ex. 1025, ¶[0002]; FFs. 7-14. Thus, a three-way catalyst is seen as an oxidation catalytic converter. Gandhi teaches that a three-way catalyst may be used in conjunction with a lean NO_x trap and NH₃-SCR catalyst (Ex. 1005, ¶[0061]), that a three-way catalyst may be used to generate ammonia upstream of the LNT/NH₃-SCR system (¶[0038]) and Figure 9 shows a three-way catalyst 14 located as the **first** exhaust gas after treatment component (¶[0059]). Dr. Kröcher's testimony does not address all the above-cited relevant portions of Gandhi's disclosure.

Dr. Kröcher also testifies that Gandhi's written description does not provide additional details as to how the three-way catalyst, the lean NO_x trap and SCR catalytic converter would be implemented. Ex. 2009, ¶ 67. That testimony seems to assert that one skilled in the art would not be able to implement the combination. However, Bandl-Konrad has not argued that any of Gandhi's claimed subject matter is not supported by an enabling disclosure. Thus, the lack of additional implementing details does not detract from the specific teachings of Gandhi's disclosure referred to above.

We find that the portions of Gandhi's disclosure cited above in combination with the remainder of the disclosure are sufficient to convey an oxidation catalytic converter as the first exhaust gas aftertreatment component, as recited in Gandhi Claims 11, 19, and 46.

3) Using an NO₂ Producing Catalytic Converter Upstream of the SCR Catalytic Converter, Reacting NO to NO₂ upstream of the NH₃-SCR Catalyst Converter and Increasing the Ratio of NO₂ in the Exhaust Gas

Claims 13, 28, 32, 35, 48, and 49

Dependent Claim 13, which depends upon base Claim 11, further comprises “an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.” Ex. 2002, Claim 13.

Dependent Claim 28, which depends upon base Claim 19, further comprises “enhancing an NO₂ ratio of the nitrogen oxides in the exhaust gas ... with an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.” Ex. 2002, Claim 28.

Similar to Claim 28, dependent Claims 32, 35, and 48 require “oxidizing a portion of NO in the exhaust gas to NO₂ in a catalyst disposed upstream of the NH₃-SCR catalyst. Ex. 2002, Claims 32, 35, and 48. Alternatively, dependent Claim 49 simply requires “reacting NO to NO₂ upstream of the NH₃-SCR catalyst.” Ex. 2002, Claim 49.

Bandl-Konrad again relies on Dr. Kröcher’s testimony that there is no written description for these features. Paper 31, pp. 11-14. We have fully considered Dr. Kröcher’s testimony which appears at ¶¶ 73-82, 87-90, 92-95, and 97-98 of his declaration (Ex. 2009). However, we do not accord Dr. Kröcher’s testimony significant weight. Dr. Kröcher has not provided an adequate reason as to why one skilled in the art would disbelieve the plain teachings of Gandhi’s disclosure.

Gandhi, in describing Figure 2 states: “As illustrated in FIG. 2, the lean NO_x adsorber emits NO, NO₂, NH₃, and N₂O. These same gases then pass through the NH₃-SCR, where NH₃ is stored.” Specification, p. 8, [0032]; FFs. 7-14. Gandhi’s

Figure 2, reproduced below, illustrates the production of NO_2 in the lean NO_x absorber.

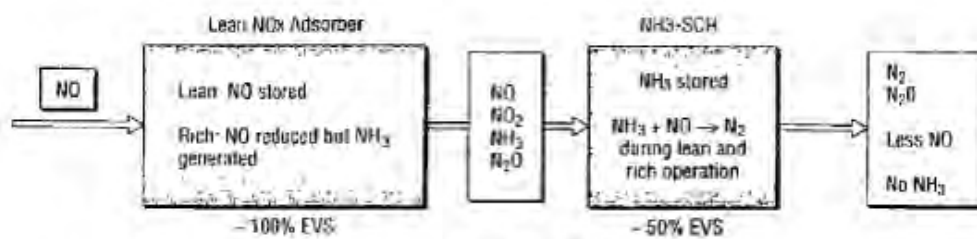


Fig. 2

As shown in Gandhi's Figure 2, exhaust gas containing NO enters the lean NO_x absorber. A combination of gases including NO_2 leaves the lean NO_x absorber and enters the NH_3 -SCR catalytic converter. Thus, Gandhi expressly describes *an* NO_2 producing catalytic converter upstream of the SCR catalytic converter and reacting NO to NO_2 upstream of the NH_3 -SCR catalyst converter.

Gandhi's disclosure is also consistent with Dr. Kröcher's testimony from his deposition on January 10, 2012. There, Dr. Kröcher admitted that a three-way catalyst ("TWC") and lean NO_x absorber (LNT), as shown in Gandhi's Figure 2, can oxidize NO to form NO_2 :

Q. You agree that a TWC can oxidize NO to form NO_2 under lean conditions; right?

A. It can do. However, only to a limited extent

Q. And you agree that Gandhi discloses a TWC upstream of the LNT, SCR system, don't you?

A. Yeah.

MR. JACOBS: Objection.

A. Correct.

BY MR. HUNTINGTON

Q. And you would agree that under lean conditions the TWC would oxidize NO to form NO_2 , wouldn't it?

A. Yes, but again only to a very limited extent. It is not a specialized NO_2 producing catalytic converter.

Q. Claim 13 does not call for a specialized NO_2 producing catalytic converter, does it?

MR. JACOBS: Objection.

A. No, that's correct.

BY MR. HUNTINGTON:

Q. And you would agree that a lean NO_x trap oxidizes NO to form
5 NO₂; right?

A. Correct.

Ex. 1028, p. 80, ll. 1-12.

Dr. Kröcher has not presented a scientific basis why Gandhi's straight
10 forward description is not valid or believable. Nor has Dr. Kröcher provided a
scientific reason why the operation of the lean NO_x absorber as described and
illustrated by Fig. 2 would not increase the "NO₂ ratio of the nitrogen oxides in the
exhaust gas." Because as illustrated in Figure 2, the NO₂ is formed during the
passage of the exhaust gas through the lean NO_x absorber, the NO₂ ratio of
15 nitrogen oxides in the exhaust gas would necessarily increase.

For these reasons, Bandl-Konrad has not satisfied its burden of establishing
that Gandhi's written description does not describe an NO₂ producing catalytic
converter upstream of the SCR catalytic converter, reacting NO to NO₂ upstream
of the NH₃-SCR catalyst converter or increasing the ratio of NO₂ ratio of nitrogen
20 oxides in the exhaust gas, as recited in Gandhi Claims 13, 28, 32, 35, 48, and 49.

4) Particulate Filter

Claims 11-13 and 20

Claim 11 and its dependent Claims 12-13 define an installation for
25 aftertreatment of exhaust gas generated by a diesel engine of a motor vehicle
comprising four required exhaust gas purification (aftertreatment) components
arranged in a specific order in relation to each other and the exhaust gas flow. Ex.
2002, Claims 11-13. As expressly defined in Gandhi Claims 11-13, the exhaust
gas flows through the four components in the following order:

1. an oxidation catalytic converter;
2. a nitrogen oxide (NO_x) storage catalytic converter;
3. a particulate filter; and
4. an SCR catalytic converter.

5 Claim 20, similarly requires the same order of components. Ex. 2002, Claim 20.

Bandl-Konrad argues, *inter alia*, that Gandhi's original specification does not provide a written description of a particulate filter "arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic
10 converter." Paper 31, pp. 6-8

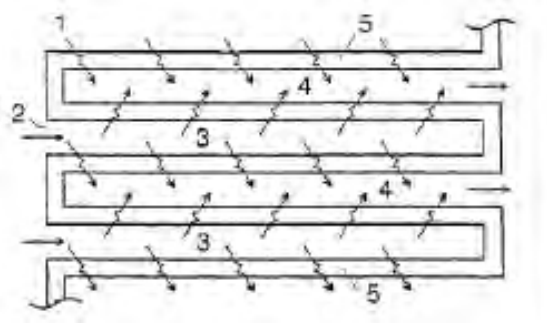
We have reviewed the Gandhi's written description and fail to see where Gandhi describes this specific arrangement. As pointed out by Bandl-Konrad, Gandhi's written description only makes a single mention of particulate filters:

15 The invention also contemplates engineering such combinations within the pores of the monolithic substrate. An example of this is incorporating washcoat into porous substrates used for filtering diesel particulate matter. Thus, this lean NO_x trap/ NH₃-SCR catalyst concept can be integrated into diesel particulate matter devices.

20 Ex. 1005, ¶[0054]. However, this paragraph is silent on the location of the particulate filter and does not describe a structure where the particulate filter is located between the two catalytic converters.

25 Gandhi's opposition does not direct us to a specific portion of the written description that expressly describes a particulate filter at the required location. Instead, Gandhi relies on the disclosure presented by Figs. 4 and 7 and the testimony of Dr. Michael Harold (Ex. 1030). Paper 40, p. 6, l. 6 – p. 8, l. 4. Dr. Harold testifies that the person having ordinary skill in the art would understand the reference to "porous substrates used for filtering diesel particulate matter" in

¶52 of Gandhi's written description refers to be "wall-flow" filters. Ex. 1030, p. 43, ¶158, ll. 11-13. Dr. Harold's testimony includes a drawing said to show how



such a filter operates. Ex. 1030, p. 43, ¶158, ll. 13-16. The drawing is reproduced below:

5

The drawing is admittedly not disclosed in Gandhi's application. Ex. 1030, p. 43, ¶158, ll. 13. Dr. Harold then combined the structure shown in the particulate filter drawing with Gandhi's Figs. 4 and 7 testifying that:

10

"the combination of the configurations shown in Figures 4 and 7 into a porous substrate for filtering diesel particulate matter would result in a system having a particulate filtering component located between a lean NO_x trap and SCR catalyst."

15

Ex. 1030, p. 50, ¶173, ll. 14-17. Dr. Harold created the drawing, reproduced below, said to be "an example" of the integration the structure of Gandhi Fig. 7b into a diesel particulate matter device: Ex. 1030, p. 50, ¶173, ll. 17-19.

Chann

Ex. 1030, p. 51. The combination drawing also is not present in Gandhi's disclosure. Nevertheless, Dr. Harold testifies that:

5 "[i]n this arrangement, the exhaust gas would contact a Lean NO_x Trap formulation, the porous substrate, and a SCR Catalyst formulation in that order."

Ex. 1030, p. 50, ¶173, ll. 19-20.

10 Dr. Harold similarly combines the "known" particulate filter structure with the arrangement shown in Gandhi's Figures 4a-4c to arrive at another structure having the sequence required by Claim 11:

15 when one applies the various configurations to the porous substrate used for particulate filtration, such as in Figure 4a, the result is a system that has an integrated Lean NO_x Trap-Particulate Filter zone, and SCR Catalyst-Particulate Filter zone, such that one has a system where a Particulate Filter is located downstream of the Lean NO_x Trap and also upstream of the SCR Catalyst.
Ex. 1030, 52:13-17.

20 Dr. Harold created the following drawing to illustrate the resultant sequence:
Ex. 1030, p. 52, ¶175.

The drawing also does not appear in Gandhi's disclosure. Dr. Harold then testifies that Gandhi has written descriptive support for a particulate filter located downstream of the lean NO_x trap and also upstream of the SCR Catalyst. Ex. 1030, p. 53, ¶176, ll. 6-7.

We do not credit Dr. Harold's testimony on these points. First, Dr. Harold's testimony does not provide any basis for the statement that that one skilled in the art would recognize that the "porous substrates used for filtering diesel particulate matter" as used in Gandhi's written description refers to "wall-flow" filters. We are not required to credit the unsupported assertions of an expert witness. *Rohm and Haas Co. v. Brotech Corp.*, 127 F.3d 1089, 1092 (Fed. Cir. 1997). See also, Standing Order, Paper 2, ¶158.1.1.

Second, to the extent "wall-flow" filters are conventional in the art, Gandhi appears to presume that whatever was conventionally known by those in the art was actually considered part of the invention by the inventors and considered to have been described in the specification. No basis exists for that presumption.

Third, the proposed combination of the undisclosed structure of "wall-flow" filters with the structures shown in Gandhi's Figures. 4 and 7 to arrive at the structures proposed by Dr. Harold's appear to be a matter of "obviousness" rather

than “written description.” As we have noted above, the test for written description is not obviousness. Rather, the specification must convey with reasonable clarity to one with ordinary skill in the art that as of the filing date of the application the inventor was in possession of the claimed invention. *Vas-Cath Inc.*, 935 F.2d at 1563-64; see also *Pandrol USA, LP*, 424 F.3d at 1165. The pertinent question in analyzing written description is: did the written description objectively tell to the person skilled in the art that the inventor contemplated the subject matter now claimed.

For the foregoing reasons, Bandl-Konrad has met its burden to establish by a preponderance of the evidence that Gandhi Claims 11-13 and 20 are unpatentable under 35 U.S.C. § 112, first paragraph, for lacking written description support for a “particulate filter” that is arranged at the specific location required by the claims, i.e., “upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter.” Accordingly, we hold that Bandl-Konrad has shown that Gandhi Claims 11-13 and 20 are unpatentable under 35 U.S.C. § 112, first paragraph, as lacking written description support.

Claims 10, 31, 34 and 47

Dependent Claims 10, 31, 34 and 47 also require a particulate filter. Each of these claims adds the specific limitation requiring “filtering particulate matter in the exhaust gas.” Ex. 2002, Claims 10, 31, 34, and 47.

Bandl-Konrad makes essentially the same arguments against Gandhi Claims 10, 31, 34 and 47 that were made with respect to Claims 11-13 and 20, i.e., that written description support is lacking because “it would not be possible to arrange the particulate filter upstream of the NH₃-SCR washcoat and downstream of the lean NO_x trap (LNT) washcoat.” Paper 31, p. 14, Ex. 2009, ¶103.

Bandl-Konrad's argument is not persuasive. We note that Gandhi Claims 10, 31, 34, and 47 do not require a specific arrangement or location for the particulate filter. Instead, those claims merely require "filtering particulate matter in the exhaust gas." Gandhi written description expressly teaches using a particulate filter. Gandhi Specification, p. 15, [0015]; FFs. 7-14. That disclosure alone is sufficient to provide written descriptive support for the broadly worded "filtering particulate matter," as recited in Gandhi Claims 10, 31, 34, and 47.

Bandl-Konrad has failed to prove that Gandhi Claims 10, 31, 34 and 47 are unpatentable under 35 U.S.C. § 112, first paragraph, for lacking a written description support.

4.

In summary, Bandl-Konrad has met its burden to prove that Gandhi Claims 11-13 and 20 are unpatentable under 35 U.S.C. § 112, first paragraph, for lacking a written description support. However, Bandl-Konrad has failed to prove that Gandhi Claims 10, 19, 28, 31, 32, 34, 35, and 46-49 are unpatentable under 35 U.S.C. § 112, first paragraph, for lacking a written description support. Therefore, Bandl-Konrad Motion 3 (Paper 31) is GRANTED as to Gandhi Claim 11-13 and 20, and is otherwise DENIED as to Gandhi Claims 10, 19, 28, 31, 32, 34, 35, and 46-49.

IV. BANDL-KONRAD MOTION 4 (PAPER 32) SEEKING ENTRY OF JUDGMENT AGAINST GANDHI BASED ON AN ALLEGED LACK OF PATENTABILITY UNDER 35 U.S.C. §§ 102 & 103

In Bandl-Konrad Motion 4 (Paper 32), Bandl-Konrad moves for judgment that Claims 9, 10, 19, 30-35, and 46-49 of Gandhi's involved application, U.S. Application Serial No. 12/706,558 ("Gandhi '558 application") (pending Claims

attached as Ex. 2002) are unpatentable over the prior art under one or both of 35 U.S.C. §§ 102 and 103. To prevail on this motion, Bandl-Konrad bears the burden of proving by a preponderance of evidence that Claims 9, 10, 19, 30-35, and 46-49 of Gandhi '558 application are unpatentable over prior art. 37 C.F.R. § 41.121(b).

Specifically, Bandl-Konrad argues: (1) Claims 9 and 46 of Gandhi's involved application are unpatentable under 35 U.S.C. §§ 102 and 103 as being anticipated or rendered obvious over Kinugasa, U.S. Patent No. 6,109,024 (Kinugasa '024; Ex. 2004); (2) Claims 19, 30, 32, 33 and 35 of Gandhi's involved application are unpatentable under 35 U.S.C. § 102(b) as being anticipated by Kinugasa '024 (Ex. 2004); (3) Claims 10, 31, 34 and 47 of Gandhi's involved application are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Kinugasa '024 (Ex. 2004) and Twigg, PCT International Application No. 00/21647 (Twigg '647; Ex. 2013); and (4) Claims 48-49 of Gandhi's involved application are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Kinugasa '024 (Ex. 2004). In addition, Bandl-Konrad also argues, pursuant to the presumption under 37 C.F.R. §41.207(c), that the asserted prior art does not anticipate or render obvious any claims of Bandl-Konrad '747 patent.

In its opposition (Paper 41), Gandhi does not contest Bandl-Konrad's general contention regarding the unpatentability of Gandhi's claims; rather, Gandhi opposes to the extent that should Gandhi Claims 9, 10, 19, 30-35, and 46-49 be held unpatentable, Bandl-Konrad Claims 1-19 should also be held unpatentable for the same reasons. Gandhi Opposition 4 (Paper 41), p. 1.

However, in light of our decision re: Bandl-Konrad Motion 3 (Paper 31) holding that Gandhi Claims 11-13 and 20 have been shown as unpatentable under 35 U.S.C. §112, first paragraph, for lack of written description support from Gandhi '558 application, and Gandhi remaining Claims 9, 10, 19, 28, 30-35, and 46-49 (including unchallenged Claims 9, 30, and 33) have not been shown as

unpatentable under 35 USC §112, first paragraph, we exercise our discretion under 37 C.F.R. §1.125(a) to review Bandl-Konrad's challenges only with respect to Gandhi remaining Claims 9, 10, 19, 28, 30-35, and 46-49. With respect to these remaining claims, Bandl-Konrad's arguments against patentability under one or both of 35 U.S.C. §§ 102(b) and 103(a) can be summarized as follows:

(1) Claims 9, 19, 30, 32, 33, 35, 46, and 49 are anticipated under 35 U.S.C. § 102(b) by Kinugasa, U.S. Patent No. 6,109,024 (Kinugasa '024; Ex. 2004); and

(2) Claims 10, 31, 34, and 47 would have been obvious under 35 U.S.C. § 103(a) over Kinugasa '024 and Twigg, PCT International Application Publication No. WO 00/21647 (Twigg '647; Ex. 2013).

Paper 32, pp. 5-13 & APPENDIX 3 (claim charts).

A. Additional Findings of Fact Kinugasa '024 Patent

28. Kinugasa '024 issued on August 29, 2000, and as such, qualifies as prior art under 35 U.S.C. §102(b) against both Bandl-Konrad '747 patent and Gandhi's 558 application and its grandparent, Gandhi '470 application. Ex. 2004, Kinugasa '024.

29. Kinugasa '024 discloses an exhaust gas purification system for an internal combustion engine, shown in Fig. 1, capable of removing NO_x in the exhaust gas of a lean burn engine with high efficiency. Kinugasa '024, col. 1, ll. 9-11; col. 6, ll. 43-46 (diesel fuel); col. 9, ll. 17-19. Fig. 1 is reproduced below.

As shown in Fig. 1, the exhaust gas purification system includes in the direction of the exhaust gas flow from engine 1, a three-way catalyst 5, a NO_x absorbing-reducing catalyst 7, and a NH₃ adsorbing-denitrating catalyst 9. The three-way catalyst 5 is arranged upstream of NO_x absorbing-reducing catalyst 7 and NH₃ adsorbing-denitrating catalyst 9, as a first exhaust gas treatment component as seen by the direction of flow of exhaust gas. The NH₃ adsorbing-denitrating catalyst 9 is arranged downstream of the NO_x absorbing-reducing catalyst 7. Ex. 2004, Fig. 1; Ex. 2014, §51.

30. The term “three-way catalyst” as used in Kinugasa ‘024 (Ex. 2004) and the term “oxidizing catalytic converter” or “catalytic capable of oxidizing” as used in Claims 9, 30, and 33 of the Bandl-Konrad ‘747 patent (Ex. 1003) are interchangeable and refer to the same technology. Declaration of Oliver Kröcher, Ph.D., in support of Bandl-Konrad Motion 4 (Paper 32), Ex. 2014, ¶¶51-52.

31. The term “NO_x absorbing-reducing catalyst” as used in Kinugasa ‘024 (Ex. 2004) and the term “nitrogen oxide absorber” as used in Claims 9, 30, and 33 of the Bandl-Konrad ‘747 patent (Ex. 1003) are interchangeable and refer to the same technology. *Id.*, ¶¶56-58.

32. The term “NH₃ absorbing-denitrating catalyst” as used in Kinugasa ‘024 (Ex. 2004) and the term “NH₃-SCR catalyst” as used in Claims 9, 30, and 33 of the Bandl-Konrad ‘747 patent (Ex. 1003) are interchangeable and refer to the same type of component. *Id.*, ¶¶64-66.

33. Kinugasa ‘024 discloses in the Background of the Invention section that it was known to operate engine cylinders with rich air-fuel ratios. Ex. 2004, Kinugasa ‘024, Background of the Invention.

34. Kinugasa ‘024 further discloses that the fuel injection valves are controlled so that the engine cylinders include alternating lean and rich air-fuel ratios. Ex. 2004, Kinugasa ‘024, Abstract.

35. Kinugasa ‘024 discloses that controlling the direct cylinder injection to the engine to generate lean and rich air-fuel ratios teaches both the specific recitation of controlling engine operations, and the broader recitation of lean and rich conditions during lean and rich cycles of Gandhi Claims 9, 30, and 33. Ex. 2004, Kinugasa ‘024, col. 6, ll. 18-26.

36. Kinugasa ‘024 discloses that the amount of NO_x produced by the engine varies depending upon air intake amount and engine speed. Ex. 2004, Kinugasa ‘024, col. 14, ll. 23-30.

37. Kinugasa ‘024 discloses that the three-way catalyst 5 receives exhaust gas from engine 1 and converts carbon hydrocarbons (HC) and carbon monoxide (CO) contained in the exhaust gas under lean conditions or when the air-fuel ratio becomes lean ($\lambda > 1.0$). Ex. 2004, Kinugasa ‘024, col. 7, ll. 6-11.

38. Kinugasa ‘024 further discloses that the catalytic material of three-way catalyst 5 is platinum Pt, rhodium Rh or palladium Pd. Ex. 2004, Kinugasa ‘024, col. 7, ll. 4-5 and 39-41.

39. In 1994, it was known that with excess oxygen, the three-way catalyst acts as an oxidation catalyst, removing all reducing species (CO, HC). Ex. 2015, M. Shelef, G.W. Graham, *Why Rhodium in Automotive Three-Way Catalysts?*, Chem. Rev. Sci. Eng. 36(3), 433-457, at 437-48 (1994). Ex. 2014, ¶18.
40. Kinugasa '024 discloses that NO_x absorbing-reducing catalyst 7 (shown in Fig. 1) receives exhaust gas from three-way catalyst 5 and absorbs NO_x in the exhaust gas in the form of nitric acid ions when the air-fuel ratio of the exhaust gas is lean (i.e., when the excess air ratio λ is larger than 1.0) and releases the absorbed NO_x when the excess air-fuel ratio λ of the exhaust gas flowing the NO_x absorbing-reducing catalyst becomes smaller than 1.0 (i.e., the air-fuel ratio becomes rich). Ex. 2004, Kinugasa '024, col. 8, ll. 13-20.
41. Accordingly, the disclosure of Kinugasa '024 of NO_x absorbing-reducing catalyst 7 (shown in Fig. 1) absorbing NO_x discloses the storing, temporarily storing, and absorbing functions of the nitrogen oxide absorber and the lean nitrogen oxide absorber as recited in Gandhi Claims 9, 30, and 33.
42. Kinugasa '024 also discloses that NO_x absorbing-reducing catalyst 7 (shown in Fig. 1) also converts NO_x in the exhaust gas to NH₃ by a mechanism exactly the same as that of the three-way catalyst. Kinugasa '024, col. 8, ll. 61-63.
43. Accordingly, the disclosure of Kinugasa '024 of NO_x absorbing-reducing catalyst 7 (shown in Fig. 1) converting NO_x to NH₃ and providing the NH₃ downstream discloses the reducing, and purging steps of Gandhi Claims 9, 30, and 33.

44. Kinugasa '024 discloses that NH_3 adsorbing-denitrating catalyst 9 is arranged downstream of the NO_x absorbing-reducing catalyst 7 (shown in Fig. 1) to adsorb the generated ammonia (NH_3) and use the adsorbed NH_3 to reduce NO_x in the exhaust gas. Ex. 2004, Kinugasa '024, col. 9, ll. 13-16 and 42-44.

45. Accordingly, the disclosure of Kinugasa '024 of NH_3 adsorbing-denitrating catalyst 9 (shown in Fig. 1) adsorbing NH_3 discloses the absorbing and storing NH_3 or absorbing in a NH_3 -SCR catalyst of Gandhi Claims 9, 30, and 33.

46. Accordingly, the disclosure of Kinugasa '024 of NH_3 adsorbing-denitrating catalyst 9 (shown in Fig. 1) reducing NO_x using NH_3 discloses the reacting step of Gandhi Claims 9, 30, and 33.

Twigg '647 Application

47. Twigg, PCT International Application Publication No. WO 00/21647 ("Twigg '647") discloses a system and method for the control of emissions of a diesel engine exhaust containing CO, HC, NO, O_2 , soot and non-reactive gases, shown in the sole drawing as reproduced below.

1

As shown in the sole figure of Twigg '647, the system comprises a catalyst 14 to convert NO to NO₂, a particulate filter 16 to collect particles, and a NO_x absorber 28 with means to regenerate the NO_x absorber by injecting reductant or other reactant upstream of the NO_x absorber, and at least during regeneration, passing the exhaust gases, via a three-way catalyst 30. Ex. 2013, Twigg '647; Abstract, p. 3, ll. 6-15, p. 7, ll. 29-30.

48. According to Twigg '647, filtering particulate matter is a well-known technique used in exhaust gas purification systems, particularly when these systems are used with engines consuming diesel fuel, such as those disclosed by Kinugasa '024. Ex. 2013; Twigg '647; Abstract; p. 3, ll. 6-15; p. 7, ll. 29-30, element 16 in the sole figure; Ex. 2004, Kinugasa '024, col. 6, ll. 43-46; also see Bandl-Konrad '747 patent, Background Section, col. 3, ll. 28-43.

Analysis

1.

Claim Construction

In determining patentability over the prior art, the name of the game is the claim. *In re Hiniker Co.*, 150 F.3d 1362, 1369 (Fed. Cir. 1998). Claim terms of an involved patent in an interference are given their broadest reasonable construction as they would be understood by one of skill in the art in light of the specification. *Rolls-Royce PLC v. United Technologies Corp.*, 603 F.3d 1325 (Fed. Cir. 2010). For purposes of a patentability or invalidity challenge under 35 U.S.C. §§ 102 and 103, the copied claims must be interpreted in light of the host disclosure, i.e., Gandhi's disclosure and file history. *Agilent Tech.*, 567 F.3d at 1375 (“[W]hen a party challenges a claim’s validity under §§ 102 and 103 ... the Board must interpret the claim in light of the specification in which it appears”). Paper No. 42, p. 5, ll. 11-14.

We will look to Gandhi's disclosure and file history to see if they provide a definition for claim terms. Otherwise, we give them their “ordinary and customary meaning” in the light of the specification that “the term would have to a person of ordinary skill in the art in question at the time of the invention, *i.e.*, as of the effective filing date of the patent application.” *Phillips v. AWH Corp.*, 415 F.3d at 1313. Neither Beckmann nor Gandhi has alleged that the inventors gave any claim term a special definition different from its recognized meaning to one with ordinary skill.

In this case, analysis of the unpatentability assertions depends on the meaning of the claim terms “nitrogen oxide absorber”, “NH₃-SCR catalyst,” “oxidizing catalytic converter” or “catalyst capable of oxidizing” as recited in Gandhi Claims 9, 30, and 33 in the context of Gandhi ‘558 application. However, as testified by Dr. Kröcher, the term “oxidizing catalytic converter” or “catalytic

capable of oxidizing” as used in Claims 9, 30, and 33 of the Bandl-Konrad ‘747 patent is interchangeable with the “three-way catalyst” as used in Kinugasa ‘024 and encompasses the same. Ex. 2014, ¶¶51-52; FFs. 5-6, and 30. Similarly, the term “nitrogen oxide absorber” as used in Claims 9, 30, and 33 of the Bandl-

Konrad ‘747 patent is interchangeable with the “NO_x absorbing-reducing catalyst” as used in Kinugasa ‘024 and refers to the same type of component. *Id.*, ¶¶56-58; FF 31. Likewise, the term “NH₃-SCR catalyst” as used in Claims 9, 30, and 33 of the Bandl-Konrad ‘747 patent is interchangeable with the term “NH₃ absorbing-denitrating catalyst” as used in Kinugasa ‘024 (Ex. 2004) and refers to the same type of component. *Id.*, ¶¶64-66; FF 32. For purposes of this decision we proceed on the basis of Dr. Kröcher’s testimony, which has not been sufficiently rebutted by Gandhi.

2.

Legal Standard for 35 U.S.C. §102(b) and §103(a)

In order to find anticipation under 35 U.S.C. §102(b), a single prior art reference must disclose each and every element of a claim, either expressly or inherently. *In re Schreiber*, 128 F.3d 1473, 1477 (Fed. Cir. 1997); *Finnigan Corp. v. Int’l Trade Comm’n*, 180 F.3d 1354, 1365 (Fed. Cir. 1999). As the moving party, Bandl-Konrad bears the burden of proof to establish entitlement to the relief requested. 37 C.F.R. § 41.121(b).

A patent claim is also unpatentable under 35 U.S.C. § 103(a) if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved on the basis of underlying factual determinations

including: (1) the scope and content of the prior art, (2) any differences between the claimed subject matter and the prior art, (3) the level of skill in the art, and (4) where in evidence, so-called secondary considerations. *Graham v. John Deere Co. of Kansas City*, 383 U.S. 1, 17-18 (1966).

Beckmann's expert, Dr. Kröcher has determined, and Gandhi has not rebutted, the appropriate level that someone of ordinary skill in the art of exhaust gas purification systems for internal combustion engines would have, that is, a bachelor's degree in chemistry, mechanical engineering, automotive engineering, or chemical engineering and seven years' work experience in the field, or a master's degree in chemistry, mechanical engineering, automotive engineering, or chemical engineering and five years' work experience in the field. Ex. 2014, ¶11. Rather, Gandhi's expert, Dr. Harold considers that a person skilled in the art to have at least 2 years of laboratory experience conducting catalyst research. Ex. 1001, ¶9; Ex. 1030, ¶46.

3.

Gandhi Claims 9, 19, 30, 32, 33, 35, 46, 48 and 49 as Anticipated by Kinugasa '024

Gandhi Claim 9 defines a method for the reduction of nitrogen oxides and ammonia from diesel engine exhaust gas, said method comprising:

storing nitrogen oxides present in the exhaust gas in a *nitrogen oxide absorber* during lean cycles with a lean exhaust gas air ratio;

reducing stored nitrogen oxides from the nitrogen oxide absorber during rich pulses, which contain a rich exhaust gas air ratio, and thereby generating ammonia;

adsorbing and storing ammonia in a *NH₃-SCR catalyst* arranged downstream of the nitrogen oxide absorber;

reacting the stored ammonia with nitrogen oxides in the *NH₃-SCR catalyst*;

operating the engine under lean conditions during lean cycles;

during lean cycles, oxidizing carbon monoxide and hydrocarbons contained in the exhaust gas in an *oxidizing catalytic converter* arranged upstream of the *nitrogen oxide absorber* and *NH₃-SCR catalyst*;

operating the engine under rich conditions during rich cycles.

Ex. 2002; Gandhi ‘558 application, Claim 9 (emphasis added).

Gandhi Claim 33 is similar to Claim 9 in scope of coverage, except that a generic “catalyst capable of oxidizing” is recited instead of “an oxidizing catalytic converter” as recited in Gandhi Claim 9. In contrast, Gandhi Claim 30 is broader in scope than Gandhi Claim 9 and does not contain limitations regarding the operation of the engine under lean conditions during lean cycles and under rich conditions during rich cycles.

Likewise, Gandhi Claims 19 and 46 are also similar to Claim 9 in scope, except that an oxidizing catalytic converter or a catalyst arranged as “a *first* exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas” is recited.

As expressly defined in Gandhi Claims 9, 19, 30, 33 and 46, there are several operative steps, including:

- Using an oxidizing catalytic converter or a catalyst arranged as a *first* exhaust gas aftertreatment component upstream from a nitrogen oxide catalytic converter and a NH₃-SCR converter, to oxidize carbon monoxide (CO) and hydrocarbons (HC);
- Using the nitrogen oxide catalytic converter to adsorb/store/reduce nitrogen oxides (NO_x) and generate ammonia (NH₃);
- Using an SCR catalytic converter arranged downstream from the nitrogen oxide catalytic converter, to adsorb/store/reduce ammonia (NH₃) released by the nitrogen oxide catalytic converter; and
- Operating the engine under lean and rich conditions.

Ex. 2002; Gandhi '558 application, Claims 9, 30, and 33.

Gandhi Claims 32, 35, and 48 depend upon Claims 30, 33, and 46 respectively, and further comprise:

“oxidizing a portion of NO in the exhaust gas to NO₂ in a catalyst disposed upstream of the NH₃-SCR catalyst.”

Ex. 2002; Gandhi '558 application, Claims 32, 35, and 48.

Gandhi Claim 49 depends upon Claim 9, and further comprises:

“reacting NO to NO₂ upstream of the NH₃-SCR catalyst.”

Ex. 2002, Gandhi '558 application, Claim 49.

In Bandl-Konrad Motion 4 (Paper 32), Bandl-Konrad contends that each and every element of Gandhi Claims 9, 19, 30, 32, 33, 35, 46, 48 and 49 is described or disclosed, either explicitly or inherently, by Kinugasa '024. Kinugasa '024 is said to “anticipate” the invention of Gandhi Claims 9, 19, 30, 32, 33, 35, 46, 48 and 49.

Specifically, Bandl-Konrad contends that Kinugasa '024 discloses an exhaust gas purification system for an internal combustion engine capable of removing NO_x in the exhaust gas of a lean burn engine with high efficiency. Kinugasa '024, col. 1, ll. 9-11; col. 6, ll. 43-46 (diesel fuel); col. 9, ll. 17-19.

Fig. 1 of Kinugasa '024 is reproduced below.

As shown in Fig. 1, the exhaust gas purification system includes in the direction of the exhaust gas flow from engine 1, a three-way catalyst 5, a NO_x absorbing-reducing catalyst 9, and a NH₃ adsorbing-denitrating catalyst 9. The three-way catalyst 5 is arranged upstream of NO_x absorbing-reducing catalyst 9 and NH₃ adsorbing-denitrating catalyst 9 as a *first* exhaust gas treatment component as seen by the direction of flow of exhaust gas. The NH₃ adsorbing-denitrating catalyst 9 is arranged downstream of the NO_x absorbing-reducing catalyst 9. Ex. 2004, Fig. 1; Ex. 2014, §51; FF 29.

Bandl-Konrad proffers detailed explanations and analyses regarding how each element of Claims 9, 19, 30, 32, 33, 35, 46, 48, and 49 of Gandhi '558 application is met by Kinugasa '024, as set forth in the claim charts attached as APPENDIX 3 – Attachments A, E, F, H, I, O, J, K, P and Q. Paper 32, pp. 5-13 & APPENDIX 3 (claim charts); FFs. 28-46.

We find Bandl-Konrad's explanations regarding Gandhi Claims 9, 19, 30, 32, 33, 35, 46, 48, and 49 persuasive and supported by the record. Gandhi has not proffered a rebuttal to Bandl-Konrad's assertions regarding Kinugasa '241. In the absence of Gandhi's opposition, we conclude that Bandl-Konrad has demonstrated by a preponderance of the evidence that Claims 9, 19, 30, 32, 33, 35, 38, 46, 48, and 49 of Gandhi's involved application are unpatentable under 35 U.S.C. § 102(b) as being anticipated by Kinugasa '024.

Gandhi Claims 10, 31, 34 and 47 as Rendered Obvious
by Kinugasa '024 and Twigg '647

Gandhi Claims 10, 31, 34 and 47 depend upon independent Claims 9, 30, 33 and 46, respectively, and further comprise "*filtering particulate matter in the exhaust gas.*" Ex. 2002, Gandhi '558 application, Claims 10, 31, 34, and 47 (emphasis added).

In Bandl-Konrad Motion 4 (Paper 32), Bandl-Konrad contends, as confirmed by Dr. Kröcher’s testimony (Ex. 2009), that filtering particulate matter is a well-known technique used in exhaust gas purification systems, particularly when these systems are used with engines consuming diesel fuel, such as those disclosed by Kinugasa ‘024, col. 6, ll. 43-46; Ex. 2013, Twigg ‘647; Abstract, p. 3, ll. 6-15, p. 7, ll. 29-30, element 16 in the sole figure; Ex. 2004; Bandl-Konrad ‘747 patent, Background Section, col. 3, ll. 28-43; FFs. 7-14, and 28-48.

Bandl-Konrad also proffers detailed explanations and analyses regarding the differences between Claims 10, 31 and 34 of Gandhi ‘558 application and the combination of Kinugasa ‘024 and Twigg ‘647, as set forth in the claim charts attached as APPENDIX 3 – Attachments D, G, I and L.

We find Bandl-Konrad’s explanations regarding Gandhi Claims 10, 31, 34 and 47 persuasive and supported by the record. Again, Gandhi has not proffered a rebuttal to Bandl-Konrad’s assertions regarding Kinugasa ‘241. In the absence of Gandhi’s opposition, we conclude that modifying Kinugasa ‘024 with the well-known “filtering” technique of Twigg ‘647 to filter particulate matter in the exhaust gas (without more) would involve nothing more than an obvious combination of prior art elements according to known methods to yield predictable results.

Thus, based on this record, we hold that Bandl-Konrad has shown by a preponderance of the evidence that Claims 10, 31, 34, and 47 of Gandhi ‘558 application are unpatentable under 35 U.S.C. § 103(a) as rendered obvious over Kinugasa ‘024 and Twigg ‘647.

Lastly, we note that Bandl-Konrad has not presented arguments against patentability of Gandhi Claim 28. However, Gandhi Claim 28 depends upon independent Claim 19, and contains similar features of Gandhi Claims 32, 35, 48, and 49. For example, Gandhi Claims 32, 35, and 48 further recite “*oxidizing a*

portion of NO in the exhaust gas to NO₂ in a catalyst disposed upstream of the NH₃-SCR catalyst.” Gandhi Claim 49 further recites “*reacting NO to NO₂* upstream of the NH₃-SCR catalyst.” Ex. 2002, Gandhi ‘558 application, Claims 32, 35, 48, and 49 (emphasis added).

As previously noted, both Gandhi independent Claim 19 and dependent Claims 35, 48, and 49 are found anticipated by Kinugasa ‘024 as Kinugasa ‘024 discloses a three-way catalyst 5 disposed upstream of NO_x absorbing-reducing catalyst 7 and NH₃ absorbing-denitrating catalyst 9, to oxidize (or react) a portion of NO in the exhaust gas to NO₂ under lean conditions. Kinugasa ‘024, col. 8, ll. 13-20; FFs. 40-46. As shown in Fig. 1 of Kinugasa ‘024, the NO₂ is formed during the passage of the exhaust gas through the NO_x absorbing-reducing catalyst 7, and the NO₂ ratio of nitrogen oxides in the exhaust gas would necessarily increase.

Similarly to Gandhi independent Claim 19 and dependent Claims 35, 48, and 49, Gandhi Claim 28 alternatively recites “*enhancing an NO₂ ratio* of the nitrogen oxides in the exhaust gas by means of a catalytic oxidation with an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.” Ex. 2002, Gandhi ‘558 application, Claim 28 (emphasis added). We see no practical difference between the subject matter of Gandhi Claims 35, 48, and 49 and Gandhi Claim 28 with respect to patentability. As such, Gandhi Claim 28 appears to have been inadvertently omitted from Bandl-Konrad Motion 4 (Paper 32). For purposes of completeness, we construe Gandhi Claim 28 as being included in Bandl-Konrad’s arguments against patentability of Gandhi Claims 19, 32, 35, 48, and 49.

Consequently, we find that one skilled in the art would have recognized that the NO₂ ratio of the nitrogen oxides in the exhaust gas could have been enhanced by way of disposing an NO₂ producing catalytic converter, and conclude that it would have been obvious to make such an enhancement by means of a catalytic

oxidation with an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.”

In summary, for the reasons discussed above, we hold that Bandl-Konrad has shown that Gandhi Claims 9, 10, 19, 28, 30-35, and 46-49 of Gandhi ‘558 application are unpatentable under 35 U.S.C. §§ 102(b) and 103(a) as being anticipated or rendered obvious over Kinugasa ‘024 and Twigg ‘647.

4.

Presumption Under 37 C.F.R. §41.207(c)

A party moving for judgment based on prior art must also explain why the prior art does not apply to the party's claims. *See Navarrini v. Worm*, 79 USPQ2d 1178, 1183 (BPAI 2005). Specifically, 37 C.F.R. §41.207(c) states:

“When a motion for judgment of unpatentability against an opponent’s claim on the basis of prior art is granted, each of the movant’s claims corresponding to the same count as the opponent’s claim will be presumed to be unpatentable in view of the same prior art unless the movant in its motion rebuts this presumption.”

Initially, Bandl-Konrad provided no explanation why Bandl-Konrad's involved claims are not unpatentable over the prior art cited in Bandl-Konrad Motion 4 (Paper 32). See 37 C.F.R. §41.207(c). Subsequently, Bandl-Konrad counsel explained that the omission was an inadvertent error and requested correction of such an error in its replies to Gandhi's opposition, which was granted in the April 30, 2012 Order (Paper 45).¹⁵

¹⁵ Typically, a reply that raises a new issue will not be considered. SO ¶122.5. However, Bandl-Konrad's belated request to address the presumption was not opposed by Gandhi and Gandhi was authorized to file a Sur-Reply in response thereto, which was granted in the April 30, 2012 Order (Paper 45).

In Bandl-Konrad Reply 4 (Paper 49), Bandl-Konrad explains why Claims 1-8, 10, 15-17, and 19 of Bandl-Konrad ‘747 patent are not unpatentable over the same prior art. However, we note that Bandl-Konrad has failed to rebut the presumption regarding Claims 9, 11-14, and 18 of Bandl-Konrad ‘747 patent. In particular, Bandl-Konrad has not explained why Claims 9, 11-14, and 18 of Bandl-Konrad ‘747 patent are not unpatentable over the same prior art, and has even admitted that Claim 9 is unpatentable over the same prior art cited in Bandl-Konrad Motion 4 (Paper 32) including Kinugasa ‘024 and Twigg ‘647. Paper 49, p. 2. Therefore, in view of Bandl-Konrad’s own admission, we hold that Bandl-Konrad has failed to rebut the presumption under 37 C.F.R. §41.207(c) and that Claims 9, 11-14, and 18 of Bandl-Konrad ‘747 patent are unpatentable over the same prior art cited therein.

Rather, Bandl-Konrad presents arguments for patentability of Bandl-Konrad Claims 1-8, 10, 15-17, and 19 by way of Dr. Oliver Kröcher’s testimony, Ex. 2025, Supplemental Declaration of Oliver Kröcher, Ph.D., in support of Bandl-Konrad Motion 4, ¶4, that none of the cited prior art, including Kinugasa ‘024 and Twigg ‘647 – either alone or in combination – discloses or suggests:

(1) a “particulate filter” arranged in a specific order, i.e., “*upstream* of the SCR catalytic converter and *downstream* of the nitrogen oxide storage catalytic converter,” as recited in Bandl-Konrad Claims 1-8 and 19;

(2) “filtering out particulates in the exhaust gas with a particulate filter arranged downstream of the nitrogen oxide storage catalytic converter and guiding filtered exhaust gas to the SCR catalytic converter” as recited in Bandl-Konrad Claims 10, 16, and 17; and

(3) “hydrogen sulfide formed during the desulfation phases is oxidized by the SCR catalytic converter” as recited in Bandl-Konrad Claim 15.

Paper 49, p. 3; Bandl-Konrad ‘747 patent, Claims 1-8, 10, 15-17, and 19.

We find Bandl-Konrad's explanations regarding Bandl-Konrad Claims 1-8, 10, 15-17, and 19 persuasive and supported by the record. Bandl-Konrad has established that the presumption does not apply to Claim 1-8, 10, 15-17 and 20 of Bandl-Konrad '747 patent.

5 In response thereto, Gandhi contends, in its Sur-Reply (Paper 51), that Claims 1-8, 10, 16, 17, and 19 of Bandl-Konrad '747 patent are unpatentable over the same prior art, including Kinugasa '024 and Twigg '647 for two reasons: First, Gandhi asserts that Bandl-Konrad has admitted that it would be obvious to add a particulate filter as taught by Twigg '647 to the system disclosed by Kinugasa '024
10 (Ex 2014, ¶¶80-81). Paper 51, p. 3. Second, Gandhi argues that, given Dr. Kröcher's contention that there are only a small, finite number of possible locations where a person of skill in the art could add a separate and distinct particulate filter to the system disclosed by Kinugasa '024 (Ex. 1037, ¶7; Ex. 1035, page, 30, ll. 5-14), it would have been obvious to add a separate and distinct
15 particulate filter to any one of the small number of possible locations in the system disclosed by Kinugasa '024. *DyStar Textilfarben GmbH & Co. Deutschland KG v.*, 464 F.3d at 1366, 80 USPQ2d at 1649 (motivation may be found in the knowledge of one skilled in the art). Paper 51, pp. 3-4.

However, we are not so persuaded by Gandhi's countervailing arguments.
20 First, Gandhi's assertion regarding Bandl-Konrad's admission is misplaced. The cited ¶¶80-81 of Exhibit 2014, Dr. Kröcher's Declaration in support of Bandl-Konrad Motion 4 (Paper 32) simply refers to the well-known "filtering" technique used in exhaust gas purification systems as discussed in connection with Gandhi Claims 10, 31, 34, and 47 and that modifying Kinugasa '024 with the well-known
25 "filtering" technique as disclosed, for example, by Twigg '647 to filter the particulate filter (without more) would involve nothing more than an obvious

combination of prior art elements according to known methods to yield predictable results. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 416 (2007).

In contrast to Gandhi Claims 10, 31, 34, and 47, Claims 1-8, 10, 16, 17 and 19 of Bandl-Konrad '747 patent require, among other features, a specific arrangement of a particulate filter, *i.e.*, "arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter." Ex. 2001; Bandl-Konrad '747 patent, Claims 1 and 10. Nowhere in Dr. Kröcher's testimony (Ex. 2014) is there any admission regarding the specific arrangement of Bandl-Konrad's claimed "particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter," as recited in Bandl-Konrad Claims 1 and 10.

Second, neither Kinugasa '024 nor Twigg '647, whether taken in combination or individually, discloses or suggests the specific arrangement of gas exhaust aftertreatment components of Bandl-Konrad's claimed "installation" including a "particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter." As such, there is no basis or articulated reasoning with some rational underpinning to support the legal conclusion of obviousness. *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006).

Gandhi further contends that Bandl-Konrad Claim 15 is unpatentable over Kinugasa '024 and Twigg '647 because Claim 15 is merely claiming the inherent function of a SCR catalyst as disclosed by Kinugasa '024. Again, we are not so persuaded by Gandhi's inherency arguments.

To establish inherency, evidence must make clear that the missing descriptive matter is necessarily present in the thing described in the reference, and that it would be so recognized by persons of ordinary skill. *In re Robertson*, 169 F.3d 743, 745 (Fed. Cir. 1999); see also *Transclean Corp. v. Bridgewood Serv. Inc.*, 290 F.3d 1346, (Fed. Cir. 2002). "Inherency . . . may not be established by

probabilities or possibilities. The mere fact that a certain thing may result from a given set of circumstances is not sufficient." *Schering Corp. v. Geneva Pharmaceuticals*, 339 F.3d 1373 (Fed. Cir. 2000). Here, Gandhi has the burden to establish that the limitation of Claim 15 was necessarily present in Kinugasa '024 and Twigg '647, and he has not done so. Gandhi's sole reference to the Shin Article to support an assertion that "it was well known in the art that various metal oxides such as vanadia (V₂O₅) were effective at catalyzing the oxidation of H₂S" is neither sufficient nor inherent within Gandhi Claim 15. Ex. 1027, Shin Article, pages 410, 413 (see Table); Ex. 1037, ¶16.

For the reasons discussed above, we hold that Bandl-Konrad has failed to rebut the presumption under 37 C.F.R. §41.207(c) regarding Claims 9, 11-14, and 18 of Bandl-Konrad '747 patent, and, as such, Claims 9, 11-14, and 18 of Bandl-Konrad '747 patent are presumed unpatentable over Kinugasa '024 and Twigg '647. However, we also hold that Bandl-Konrad has established that the presumption does not apply to Claim 1-8, 10, 15-17 and 20 of Bandl-Konrad '747 patent.

V. GANDHI SUBSTANTIVE MOTION 1 (PAPER 26) SEEKING ENTRY OF JUDGMENT AGAINST BANDL-KONRAD BASED ON AN ALLEGED LACK OF PATENTABILITY UNDER 35 U.S.C. §§ 102 & 103

In its Substantive Motion 1 (Paper 26), Gandhi moves for judgment that Claims 1-19 of Bandl-Konrad '747 patent are unpatentable over the prior art under one or both of 35 U.S.C. §§ 102(e) and 103(a). Gandhi bears the burden of proof on this matter.

In light of our decision regarding unpatentability of Bandl-Konrad Claims 9, 11-14, and 18, we only need to address Gandhi's motion with respect to Bandl-Konrad remaining Claims 1-8, 10, 15-17 and 19. With respect to the remaining

Claims 1-8, 10, 15-17 and 19 of Bandl-Konrad ‘747 patent in this interference, Gandhi’s arguments against patentability under 35 U.S.C. § 103(a) can be summarized as follows:

(1) Bandl-Konrad Claims 1, 4, 5, 7, and 10 would have been obvious over Gandhi grandparent application, Gandhi ‘470 application and Khair ‘096;

(2) Bandl-Konrad Claims 2, 3, 6, 8, 16, 17, and 19 recite additional well-known limitations and would have been obvious over Gandhi ‘470 application and Khair ‘096 in view of the knowledge of a skilled artisan as represented by several other prior art references;¹⁶ and

(3) Bandl-Konrad Claim 15 would have been obvious over Gandhi ‘470 application and an article entitled “*Claus Catalysis and H₂S Selective Oxidation*” by Anne Pieplu (“Pieplu Article”) (Ex. 1014).

Paper 26, pp. 1-17 & APPENDIX 1 (claim charts).

A. Additional Findings of Fact Gandhi ‘470 Application

49. Gandhi ‘470 application, the grandparent application of Gandhi’s involved application (Gandhi ‘558 application), discloses the same

¹⁶ The additional prior art cited by Gandhi Motion 1 (Paper 26) includes Khair, U.S. Patent No. 6,293,096 (“Khair ‘096”; Ex. 1006), Cooper, U.S. Patent No. 4,902,487 (“Cooper ‘487”; Ex. 1007), Andreasson, WO Patent Application Pub. No. 99/39809 (“Andreasson WO ‘809”; Ex. 1008), Boegner, U.S. Patent No. 6,170,259 (“Boegner ‘259”; Ex. 1010), Gray, U.S. Patent Application Pub. No. 2001/0045090 (“Gray ‘090”; Exhibit 1011), Kolmanovsky, U.S. Patent No. 6,347,512 (“Kolmanovsky ‘512”; Ex. 1012), Kaneko, U.S. Patent No. 7,127,883 (“Kaneko ‘883”; Ex. 1013), Kuenstler, U.S. Patent No. 6,594,990 (“Kuenstler ‘990”; Ex. 1015) and Pfeiffer, U.S. Patent Application Pub. No. 2002/0054844 (“Pfeiffer ‘844”; Ex. 1016).

catalyst system, shown in Fig. 2, capable of simultaneously eliminating ammonia emissions and improving net NO_x conversion. Gandhi '470 application, ¶[0033]. Fig. 2 is reproduced below.

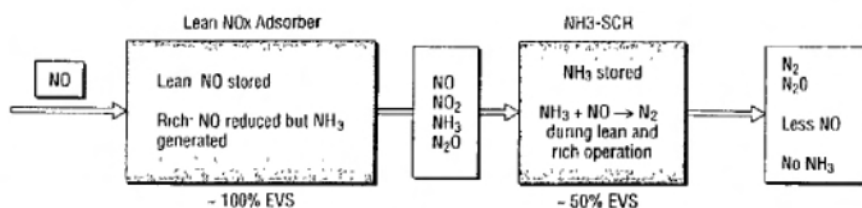


Fig. 2

As shown in Fig. 2, the catalyst system includes a lean NO_x trap and an NH_3 -SCR catalyst. As expressly described by Gandhi '470 application:

“The advantage of the catalyst system of this invention is the use of a combination of a lean NO_x trap and an NH_3 -SCR catalyst. The use of a lean NO_x trap in the present system allows for much greater storage of NO_x , because the NO_x breakthrough that would otherwise happen can be controlled by the NH_3 -SCR catalyst. Additionally, the use of a lean NO_x trap as part of this system allows for the operation of the engine at lean conditions for a longer time, and thus provides improved fuel economy Thus the combination of a lean NO_x trap and NH_3 -SCR catalyst allows for significant NO_x storage and ammonia production and thus increases net NO_x conversion.”

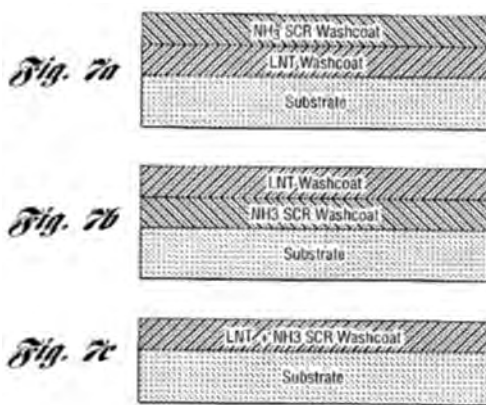
Ex. 1005; Gandhi '470 application, ¶[0044] (emphasis added).

In a preferred embodiment of Gandhi '470 application, the combination of a lean NO_x trap and an NH_3 -SCR catalyst (shown in Fig. 2) is implemented as an adjacent or alternating lean NO_x trap and NH_3 -SCR catalyst zones arranged on a single substrate or a single catalytic converter can, as shown in Figs. 4a-4c (reproduced below).

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Ex. 1005; Gandhi '470 application, ¶¶45-47; Figs. 4a-4c.

51. In another preferred embodiment of Gandhi '470 application, the combination of a lean NO_x trap and an NH₃-SCR catalyst (as shown in Fig. 2) is implemented as a lean NO_x trap washcoat and an NH₃-SCR washcoat applied to a single substrate, as shown in Figs. 7a-7c (reproduced below).



As shown in Figs. 7a-7b, the lean NO_x trap washcoat and NH₃-SCR washcoat are formed on the bottom and top layer of a substrate, respectively. In contrast, Fig. 7c involves the use of a one layer washcoat containing both lean NO_x trap and NH₃-SCR washcoat formulations. Ex. 1005; Gandhi '470 application, ¶¶[0051]-[0052]; Figs. 7a-7c.

52. In the context of the washcoat arrangement shown in Figs. 7a-7c, Gandhi '470 application also describes that:

Khair ‘096 Patent

54. Khair, U.S. Patent No. 6,293,096 (“Khair ‘096”) issued on September 25, 2001, and as such, qualifies as prior art under 35 U.S.C. §102(b) against Bandl-Konrad ‘747 patent. Ex. 1006; Khair ‘096.

5 55. Khair ‘096 discloses an exhaust gas multiple stage aftertreatment system for reducing the amount of nitrogen oxide (NO_x) and particulate matter in engine exhaust gases, and includes a first stage to oxidize NO to NO₂, a second stage to reduce a portion of NO₂ to N₂, and a third stage to further reduce a remaining portion of the NO₂ to N₂ and oxide carbon to CO₂.

10 Ex. 1006; Khair ‘096, col. 1, ll. 5-12.

56. In a first preferred embodiment of Khair ‘096, shown in Fig. 1, the multiple stage aftertreatment system “effectively combines the functions of a CRT (catalytically regenerated trap), a LNT (lean NO_x trap) and a carbon trap in a single system for the reduction of both NO_x (nitrogen oxides) and PM (particulate matter) emissions.” Ex. 1006; Khair ‘096, 15 col. 4, ll. 5-9 (emphasis added).

Fig. 1 of Khair ‘096 (annotated version) is reproduced below:

20 As shown in Fig. 1, the first stage 10 has an inlet 12 adapted to receive exhaust gases from an internal combustion engine, such as a

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JA0062

Analysis

1.

Bandl-Konrad Claims 1 and 10 as Patentably Distinguishable over Gandhi '470 application and Khair '096

Bandl-Konrad Claim 1 defines an installation for aftertreatment of exhaust gas generated by a diesel engine of a motor vehicle, said installation comprising:

a *nitrogen oxide storage catalytic converter* configured for temporarily storing nitrogen oxides contained in the exhaust gas during adsorption operating phases with a lean exhaust gas air ratio and, releasing and reducing stored nitrogen oxides during regeneration operating phases with a rich exhaust gas air ratio;

an *SCR catalytic converter* arranged downstream of the nitrogen oxide storage catalytic converter, said SCR catalytic converter being configured to receive and store ammonia generated by the nitrogen oxide storage catalytic converter, and to reduce nitrogen oxides in the exhaust gas with the stored ammonia;

a *particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter*; and

an *oxidation catalytic converter* arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas.

Ex. 1003, Bandl-Konrad Claim 1 (emphasis added).

Bandl-Konrad Claim 10 depends upon Claim 9 and recites similar limitations of Claim 1, i.e., “further comprising filtering out particulates in the exhaust gas with a *particulate filter arranged downstream of the nitrogen oxide storage catalytic converter* and guiding filtered exhaust gas *to the SCR catalytic converter*.” Ex. 1003, Bandl-Konrad Claim 10 (emphasis added).

In order to establish a *prima facie* case of obviousness, Gandhi must show that each and every limitation of the claim is described or suggested by the prior art or would have been obvious based on the knowledge of those of ordinary skill in

the art. *In re Fine*, 837 F.2d 1071, 1074 (Fed. Cir. 1988). However, “rejections on obviousness cannot be sustained with mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.” *In re Kahn*, 441 F.3d 977, 988 (Fed. Cir. 2006) cited with approval in *KSR International Co. v. Teleflex Inc.*, 550 U.S. 398, 418 (2007).

In Gandhi Substantive Motion 1 (Paper 26), Gandhi acknowledges that Gandhi ‘470 application does not disclose a separate “particulate filter” component located between two separate lean NO_x trap and SCR catalyst, i.e., a “*particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter*,” as recited in Bandl-Konrad Claim 1, and similarly recited in Claim 10. Paper 26, p. 9. Gandhi even admits that Gandhi ‘470 application only discloses filtering in the context of using washcoats into a porous substrate for filtering particulate matter, shown in Figs. 7a-7c. Ex. 1005; Gandhi ‘470 application, p. 5, ¶[0053]; Ex. 1001, ¶[29]; FFs 49-53.

Nevertheless, Gandhi, relying solely on Dr. Harold’s testimony, argues that “it would have been obvious to place a particulate filter between the Lean NO_x Trap and SCR Catalyst taught in Gandhi in view of Khair ‘096” and “it would have been obvious ... to place an SCR Catalyst downstream of an oxidizing catalyst – Lean NO_x Trap – Particulate Filter configuration disclosed in Khair ‘096 to further remove NO_x from the exhaust gas using reductant stored in the SCR Catalyst.” Paper 29, pp. 9-11; Ex. 1001, ¶[27-30].

We are not persuaded by Gandhi’s arguments against patentability of Bandl-Konrad Claims 1 and 10. Nor do we find Dr. Harold’s testimony sufficient in terms of specific facts as to why a person of ordinary skill in the art would incorporate teachings of Khair ‘096 (Ex. 1006; FFs 54-59) into a catalyst system of

Gandhi '470 application (Ex. 1005; FF 49-53) in order to arrive at the invention of Bandl-Konrad Claims 1 and 10 (Ex. 2001; FFs 15-27).

First of all, Gandhi '470 application discloses a catalyst system, shown in Fig. 2, using a combination of a lean NO_x trap and NH₃-SCR catalyst. Ex. 2001; Gandhi '470 application, ¶44; FF 49. In a first preferred embodiment of Gandhi '470 application, the combination of a lean NO_x trap and a NH₃-SCR catalyst is implemented as alternating lean NO_x trap and NH₃-SCR catalyst zones arranged on a single substrate or a single catalytic converter can, shown in Figs. 4a-4c (reproduced below).



Ex. 1005, Gandhi '470 application, ¶¶45-47; Figs. 4a-4c; FF 50.

In a second preferred embodiment, the combination of a lean NO_x trap and a NH₃-SCR catalyst is implemented as a lean NO_x trap washcoat and an NH₃-SCR washcoat applied to a single substrate, shown in Figs. 7a-7c (reproduced below).

Fig. 7c

Ex. 1005; Gandhi ‘470 application, ¶¶51-52; Figs. 7a-7c; FF 51.

In connection with the second preferred embodiment shown in Figs. 7a-7c, Gandhi ‘470 application already discloses “filtering: in the context of using washcoats in a porous substrate for filtering particulate matter. As such, we disagree with Dr. Kröcher’s characterization that:

“it would not be possible to arrange a particulate filter upstream of the NH₃-SCR washcoat and downstream of the lean NO_x trap (LNT) washcoat because the washcoats are not arranged upstream or downstream from one another, but instead are arranged in layers running parallel to the exhaust gas flow from the engine to the tailpipe.”

Paper 31, pp. 6-8; Ex. 2009, ¶61; Ex. 2018, ¶31.

The dispositive question is whether it would have been obvious for a person skilled in the art to arrange a particulate filter upstream of the NH₃-SCR washcoat and downstream of the lean NO_x trap (LNT) washcoat, shown in Figs. 7a-7c of Gandhi ‘470 application. On that question, Gandhi has provided no evidence to support these assertions apart from mere conclusory statements. It is well settled that mere lawyer’s arguments and conclusory statements, which are unsupported by factual evidence, are entitled to little probative value. *In re Geisler*, 116 F.3d 1465, 1470 (Fed. Cir. 1997); *In re De Blauwe*, 736 F.2d 699, 705 (Fed. Cir. 1984).

Based on this record, we see no reason for one skilled in the art to incorporate any additional layer of particulate filter as disclosed by Khair '096 in the manner suggested by Bandl-Konrad. Paper 37, pp. 7-11.

With respect to the first preferred embodiment shown in Figs. 4a-4c, Gandhi '470 application does not disclose arranging any particulate filter in connection with alternating lean NO_x trap and NH₃-SCR catalyst zones on a single substrate.

As a secondary reference, Khair '096 does not cure the deficiencies of Gandhi '470 application in order to arrive at Bandl-Konrad Claims 1 and 10 and their respective dependent Claims 2-8, 16-17 and 19. Contrary to Gandhi's assertion, Khair '096 simply discloses the arrangement of a carbon trap 32, 132 or the so called "particulate filter" either downstream of the lean NO_x trap 22 (Ex. 1006; Khair '096, Fig. 1) or downstream of the oxidation catalyst 114 but upstream of the lean NO_x trap 122 (Ex. 1006; Khair '096, Fig. 2). Khair '096 does not disclose or suggest a separate "particulate filter" component located between a lean NO_x trap and an SCR catalyst, i.e., a "*particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter,*" as recited in Bandl-Konrad Claim 1, and similarly recited in Claim 10. Ex. 1006; Khair '096, FFs 49-54.

Even if the particulate filter as disclosed by Khair '096 can be arranged either downstream of the lean NO_x trap 22 or upstream of the lean NO_x trap 122 and, as such, can be combined with alternating lean NO_x trap and NH₃-SCR catalyst zones on a single substrate, shown in Figs. 4a-4c of Gandhi '470 application, we conclude that the combination of Gandhi '470 application and Khair '096 still does not arrive at the invention of Bandl-Konrad Claims 1 and 10.

For the foregoing reasons, Gandhi has not met its burden to show that Bandl-Konrad Claims 1 and 10 are unpatentable over Gandhi '470 application and Khair '096. Claims 2-8 and 19 depend upon Claim 1, and Claims 16-17 depend

upon Claim 10. Accordingly, Bandl-Konrad has not shown that Claims 1-9, 10, 16, 17 and 19 are unpatentable over Gandhi '470 application and Khair '096.

Even assuming *arguendo* that Gandhi has met its burden to show that Bandl-Konrad Claims 1 and 10 are unpatentable over Gandhi '470 application and Khair '096, we nevertheless agree with Bandl-Konrad's countervailing arguments and Dr. Kröcher's testimony that Gandhi '470 application contains numerous disclosures that would have discouraged one skilled in the art from incorporating a filter between the disclosed lean NO_x trap and NH₃-SCR catalytic converter shown in Figs. 4a-4c. Paper 37, pp. 7-11; Ex. 2018. For example, Dr. Kröcher testifies that:

First, the Gandhi '470 application discloses that it is desirable to arrange the lean NO_x trap and SCR catalytic converter as close as possible to avoid unwanted conversion of ammonia back to NO_x ... Positioning a filter between the catalysts as required by Claim 1 would in fact be discouraged in view of the Gandhi '470 application because one skilled in the art would not have desired to reduce the amount of ammonia and increase the amount of NO_x that would occur due to an increased separation between the lean NO_x trap and SCR catalytic converter (Ex. 2018, ¶37).

Second, arranging a particulate filter between the lean NO_x trap and the SCR catalytic converter would have increased the overall cost of the system because Gandhi discloses that configuring the lean NO_x trap and the SCR catalytic converter on a single substrate significantly reduces costs. *See, e.g.*, Ex. 1005, Gandhi '470 application, ¶ 0056 ("the incorporation of both a lean NO_x trap and NH₃-SCR washcoat into a single substrate will significantly reduce substrate costs."). Indeed, since Gandhi contemplates incorporating the catalysts on a single substrate, there is no explanation as to how a particulate filter could be arranged upstream of an SCR catalytic converter and downstream of a NO_x catalytic converter in this way. (Ex. 2018, ¶38).

Third, arranging a particulate filter between the lean NO_x trap and the SCR catalytic converter would reduce the amount of NO₂ available for the SCR catalytic converter, which would have been

undesirable because NO₂ promotes the operations of the SCR catalytic converter. The Khair ‘096 patent expressly discloses that the carbon trap oxidizer 32 reduces the amount of NO₂ ... Thus, one skilled in the art would not have combined the NO₂ reducing filter of the Khair ‘096 patent with the catalyst arrangement of the Gandhi ‘470 application as the operation of the SCR catalytic converter would be adversely affected. (Ex. 2018, ¶39).

We are persuaded by Dr. Kröcher’s testimony that Gandhi ‘470 application contains disclosures that would have discouraged one skilled in the art from incorporating a filter between the disclosed lean NO_x trap and NH₃-SCR catalytic converter shown in Figs. 4a-4c. As such, and based on the disclosures of Gandhi ‘470 application and Khair ‘096, no *prima facie* case of obviousness can be made against Bandl-Konrad Claims 1 and 10 under 35 U.S.C. § 103(a).

With respect to Bandl-Konrad remaining Claim 15 which depends on Claim 9, via Claim 13, Gandhi further argues that “it would have been obvious to one of ordinary skill in the art that during a desulfation, hydrogen sulphide (H₂S) present in the exhaust gas would be oxidized in the SCR catalytic converter based on the chemistry underlying the oxidation of H₂S and SCR Catalysts” as evidenced by, *inter alia*, Kaneko ‘883 and Pieplu Article. Ex. 1001, ¶¶80-82; FF 60-61. Bandl-Konrad has not offered any rebuttal. Therefore, in the absence of Bandl-Konrad’s opposition, we agree with Gandhi and hold that Gandhi has not shown that Claim 15 is unpatentable under 35 U.S.C. §103(a) over Gandhi ‘470 application, Kaneko ‘883 and Pieplu Article.

VI. CONCLUSIONS

Based on the record before us, we conclude that Bandl-Konrad has met its burden to show by the preponderance of evidence that all Gandhi Claims 9-13, 19, 20, 28, 30-35, and 46-49 of Gandhi’s involved application (Gandhi ‘558

application) are unpatentable under 35 U.S.C. §§102, 103 and 112, first paragraph. Specifically, Bandl-Konrad has shown that: (1) Claims 11-13 and 20 of Gandhi's involved application are unpatentable under 35 U.S.C. § 112, first paragraph, as lacking written description in Bandl-Konrad Motion 3 (Paper 31); and (2) remaining Claims 9-10, 19, 28, 30-35, and 46-49 of Gandhi's involved application are unpatentable under 35 U.S.C. §§ 102 and 103 over prior art, including Kinugasa '024 and Twigg '647 in Bandl-Konrad Motion 4 (Paper 32).

We also conclude that: (1) Bandl-Konrad has failed to rebut the presumption under 37 C.F.R. §41.207(c) regarding Claims 9, 11-14, and 18 of Bandl-Konrad ‘747 and, as such, Claims 9, 11-14, and 18 of Bandl-Konrad ‘747 patent are considered unpatentable over the same prior art, including Kinugasa ‘024 and Twigg ‘647; and (2) Gandhi has not shown that Bandl-Konrad Claims 1-8, 10, 15-17, and 19 of Bandl-Konrad ‘747 patent are unpatentable over Kinugasa ‘024 and Twigg ‘647.

We further conclude that Gandhi has not met its burden to show that Bandl-Konrad Claims 1-8, 10, 16-17, and 19 are unpatentable over Gandhi grandparent ‘470 application and Khair ‘096. However, Gandhi has shown that Bandl-Konrad Claim 15 is unpatentable over Gandhi ‘470 application, Khair ‘096 and Pieplu Article.

As a result of the above decisions, Gandhi no longer has any patentable claims, and Bandl-Konrad remaining Claims 1-8, 10, 16-17, and 19 have not been shown to be unpatentable. Because there currently is no basis for formulating a count representing the common patentable subject matter of the parties for determining priority, it is appropriate to terminate the interference at this point. Consequently, we need not reach Bandl-Konrad Motion 1 (Paper 29) to substitute new Count and Bandl-Konrad contingent Motion 2 (Paper 30) to re-designate claims corresponding to the substituted new Count. Therefore, Bandl-Konrad

Motion 1 (Paper 29) and Bandl-Konrad contingent Motion 2 (Paper 30) are
 DISMISSED.

VII. ORDER

For the reasons discussed above, it is:

ORDERED that Bandl-Konrad Motion 3 (Paper 31) alleging lack of
 patentability under 35 U.S.C. § 112, first paragraph, as lacking written description
 support is GRANTED as to Gandhi Claims 11-13 and 20, but is DENIED as to
 Gandhi Claims 9-10, 19, 28, 30-35, and 46-49 (including unchallenged Claims 9,
 30, and 33);

FURTHER ORDERED that Bandl-Konrad Motion 4 (Paper 32) alleging
 lack of patentability of Gandhi remaining Claims 9-10, 19, 28, 30-35, and 46-49
 under 35 U.S.C. §§ 102 and 103 is GRANTED;

FURTHER ORDERED that, because Bandl-Konrad did not overcome the
 presumption under 37 C.F.R. §41.207(c) that its own claims were unpatentable for
 the same reasons set forth for Gandhi's involved claims, and as such, we hold that
 Claims 9, 11-14, and 18 of Bandl-Konrad '747 patent are also unpatentable under
 35 U.S.C. §§ 102 and 103 over the same prior art cited in Bandl-Konrad Motion 4
 (Paper 32);

FURTHER ORDERED that Bandl-Konrad overcame the presumption
 under 37 C.F.R. §41.207(c) as to Claims 1-8, 10, 15-17 and 20 of Bandl-Konrad
 '747 patent;

FURTHER ORDERED that Gandhi Substantive Motion 1 (Paper 26)
 alleging lack of patentability under 35 U.S.C. §§ 102 and 103 is GRANTED as to
 Claims 9, 11-15, and 18 of Bandl-Konrad '747 patent, and is otherwise DENIED
 as to Claims 1-8, 10, 16, 17, and 19 of Bandl-Konrad '747 patent;

5 new Count are DISMISSED as MOOT;

Bandl-Konrad '747 patent in a separate paper;

10 **FURTHER ORDERED** that a copy of this decision shall be entered into
the files of Bandl-Konrad's involved patent, U.S. Patent No. 7,814,747 and
Gandhi's involved application, U.S. Patent Application No. 12/706,558.

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ADDENDUM 2

July 26, 2013 Order, Brigitte Bandl-Konrad et al. v. Haren S. Gandhi et al.,
Patent Interference No. 105,839 (P.T.A.B.)
(Paper 126)

JA0075-77

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Paper No. 126
Entered: July 26, 2013

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**BRIGITTE BANDL-KONRAD, ANDREAS HERTZERG,
BERND KRUTZSCH, ARNO NOLTE, MARKUS PAULE,
STEFAN RENFFTLEN, NORBERT WALDBUESSER,
MICHEL WEIBEL, GUENTER WENNINGER, and
ROLF WUNSCH**
Junior Party
(Patent No. 7,814,747)

v.

**HAREN S. GANDHI, JOHN VITO CAVATAIO,
ROBERT HENRY HAMMERLE, and
YISUN CHENG**
Senior Party
(Application 12/706,558)

Patent Interference No. 105,839 (HHB)

Before RICHARD E. SCHAFER, RICHARD TORCZON, and HUNG H. BUI,
Administrative Patent Judges.

BUI, *Administrative Patent Judge.*

JUDGMENT – 37 CFR §41.127(a)

5 prior art; and (3) Bandl-Konrad Claims 9, 11-15, and 18 of Bandl-Konrad ‘747
patent are unpatentable over prior art. Paper 125. Without any patentable claims
from Gandhi, there is no basis for formulating a count representing the common
patentable subject matter of the parties for determining priority. It is appropriate,
therefore, to terminate the interference at this point and enter judgment.

10 For the reasons discussed above, it is:

ORDERED that Junior Party, Bandl-Konrad Claims 9, 11-15, and 18 (corresponding to Count 1) of Bandl-Konrad ‘747 patent will be cancelled pursuant to 35 USC §135(a);

15 46-49 (corresponding to Count 1) of Gandhi's involved application (Gandhi '588
application) are finally refused pursuant to 35 USC §135(a);

FURTHER ORDERED that a copy of this judgment be made of record in the files of Bandl-Konrad's involved patent, U.S. Patent No. 7,814,747 and Gandhi's involved application, U.S. Patent Application No. 12/706,558;

20 **FURTHER ORDERED** that if there is any settlement agreement or related documents which have not been filed, attention is directed to 35 U.S.C. §135(c) and 37 C.F.R. §41.205.

cc (e-mail):

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ADDENDUM 3

U.S. Patent No. 7,814,747

JA0087-103



US007814747B2

(12) **United States Patent**
Bandl-Konrad et al.

(10) **Patent No.: US 7,814,747 B2**(45) **Date of Patent: *Oct. 19, 2010**

(54) **EXHAUST GAS AFTERTREATMENT
INSTALLATION AND METHOD**

(75) Inventors: **Brigitte Bandl-Konrad**, Goeppingen (DE); **Andreas Hertzberg**, Markgroeningen (DE); **Bernd Krutzsch**, Denkendorf (DE); **Arno Nolte**, Stuttgart (DE); **Markus Paule**, Korb (DE); **Stefan Renfflen**, Eislingen (DE); **Norbert Waldbuesser**, Stuttgart (DE); **Michel Weibel**, Stuttgart (DE); **Guenter Wenninger**, Stuttgart (DE); **Rolf Wunsch**, Malsch (DE)

(73) Assignee: **Daimler AG**, Stuttgart (DE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 805 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/690,214**

(22) Filed: **Mar. 23, 2007**

(65) **Prior Publication Data**
US 2007/0175208 A1 Aug. 2, 2007

Related U.S. Application Data

(63) Continuation of application No. 10/541,311, filed as application No. PCT/EP2003/014313 on Dec. 16, 2003, now Pat. No. 7,210,288.

(30) **Foreign Application Priority Data**
Jan. 2, 2003 (DE) 103 00 298

(51) **Int. Cl.**
F01N 3/00 (2006.01)

(52) **U.S. Cl.** 60/297; 60/274; 60/286; 60/295; 60/301; 60/303; 422/178; 422/212; 423/213.2; 423/213.5; 423/213.7; 423/239.1

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See application file for complete search history.

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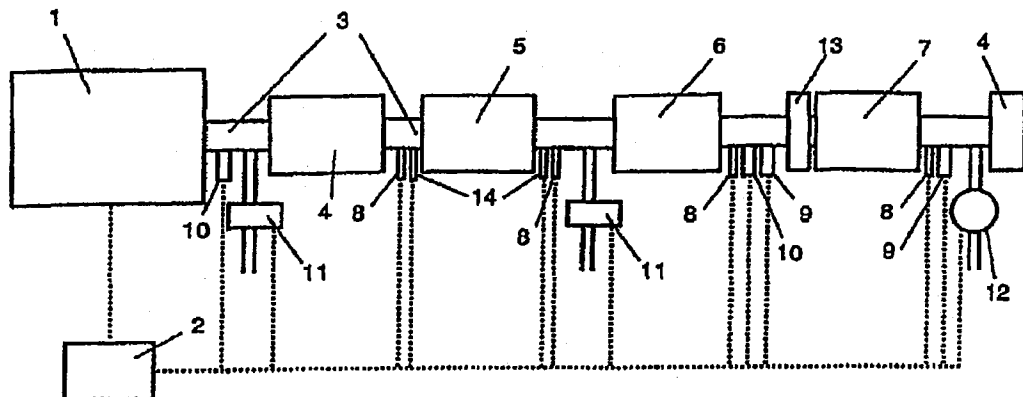
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(57) **ABSTRACT**

An exhaust gas aftertreatment installment and associated exhaust gas aftertreatment method utilizes a nitrogen oxide storage catalytic converter and an SCR catalytic converter. A particulate filter is provided upstream of the nitrogen oxide storage catalytic converter or between the latter and the SCR catalytic converter or downstream of the SCR catalytic converter. The time of regeneration operating phases of the nitrogen oxide storage catalytic converter can be determined as a function of the nitrogen oxide content of the exhaust gas downstream of the nitrogen oxide storage catalytic converter or of the SCR catalytic converter and/or as a function of the ammonia loading of the latter. Moreover, a desired ammonia generation quantity can be determined for a respective regeneration operating phase. The installation and method are adopted for use for motor vehicle internal combustion engines and other engines which are operated predominantly in lean-burn mode.

19 Claims, 4 Drawing Sheets



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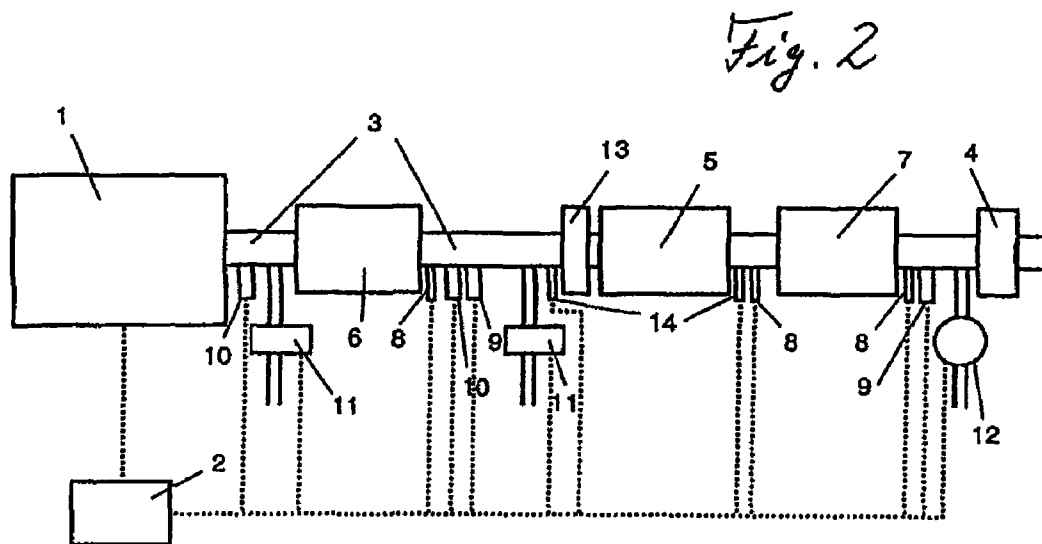
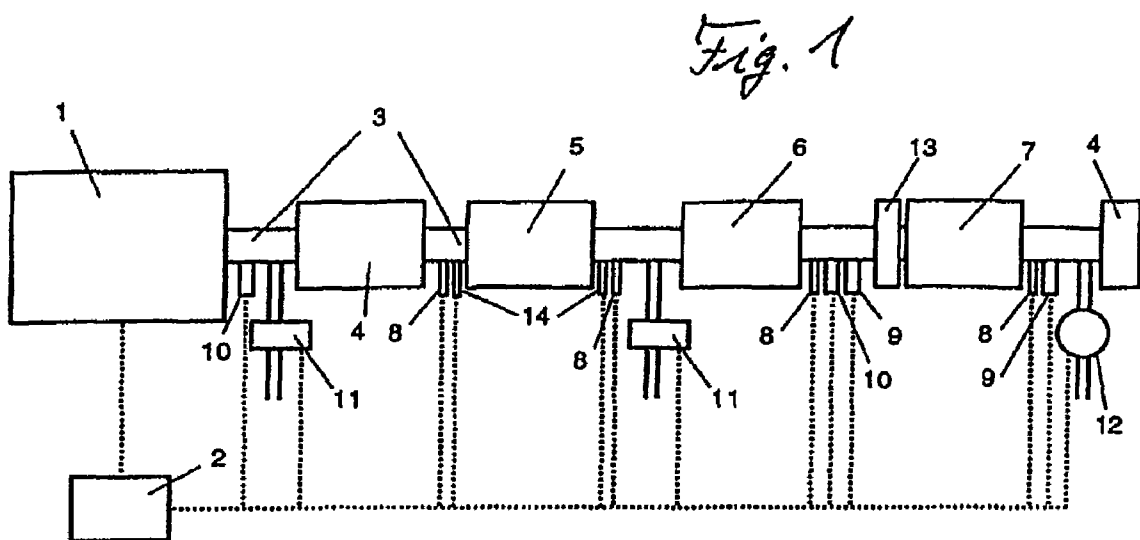
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Fig. 3

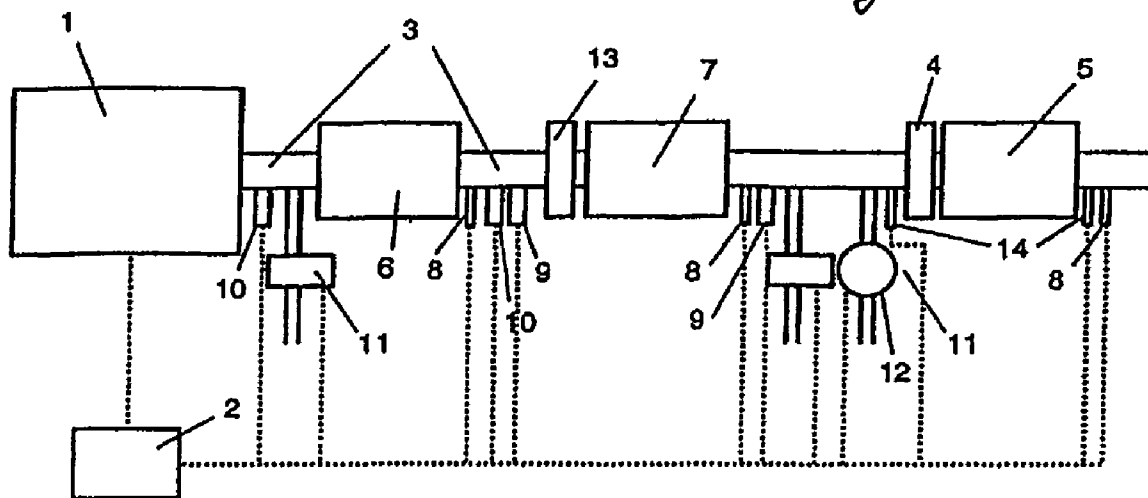
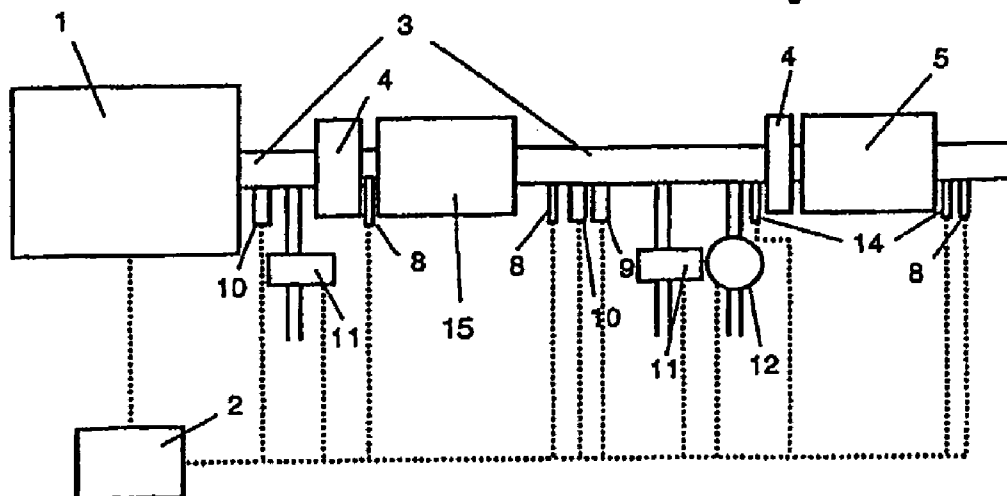


Fig. 4



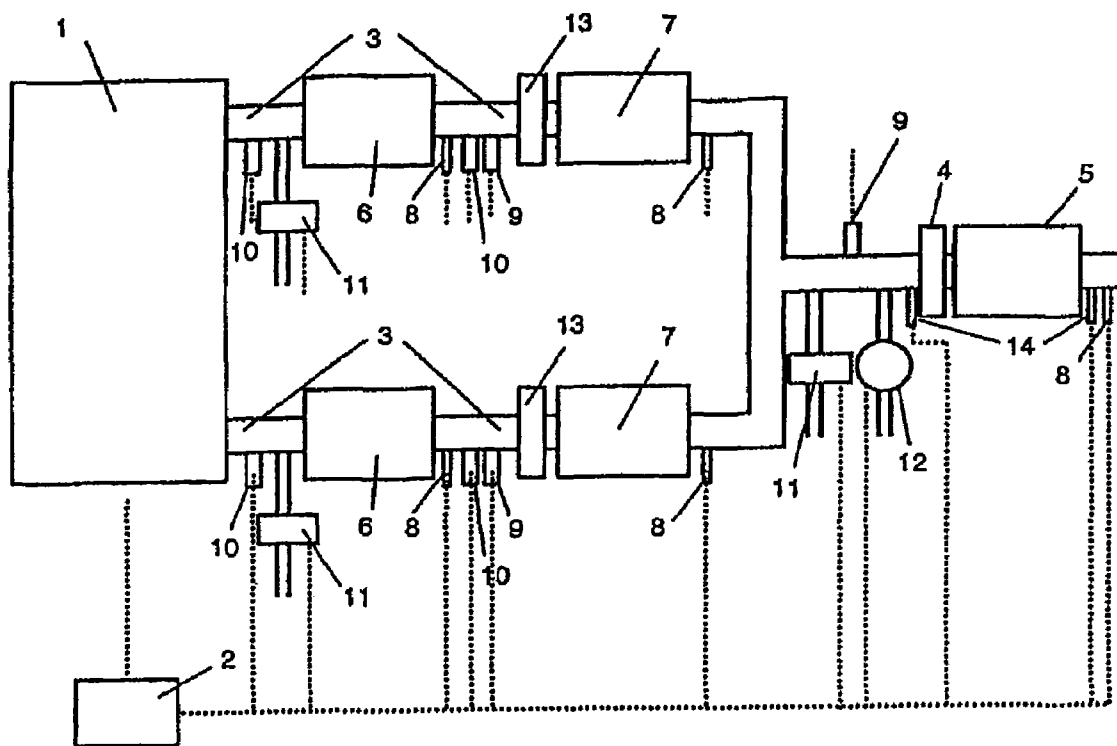
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Fig. 5

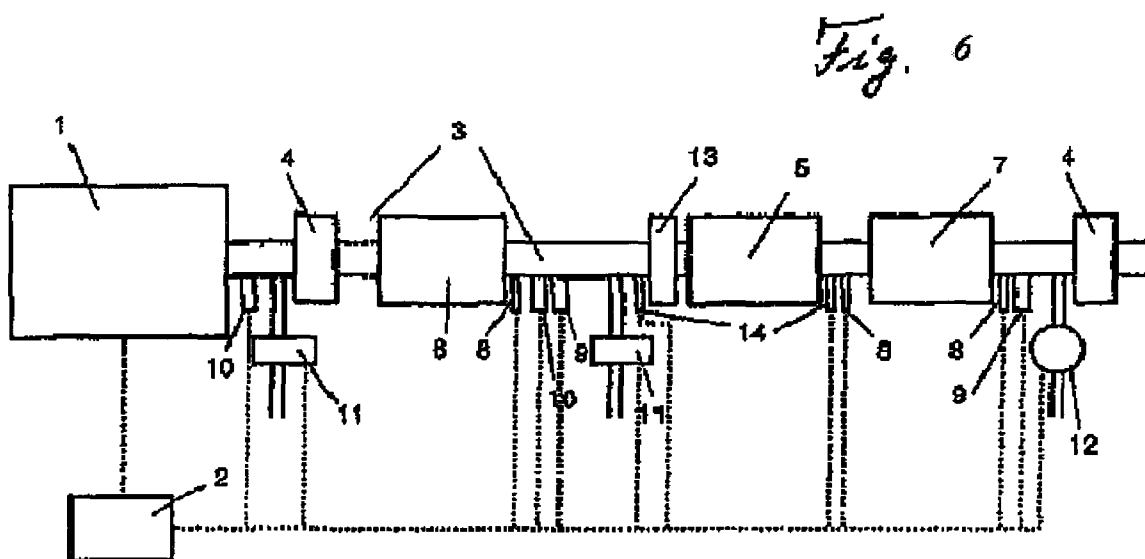


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**EXHAUST GAS AFTERTREATMENT
INSTALLATION AND METHOD****CROSS-REFERENCE TO RELATED
APPLICATIONS**

This application is a continuation of U.S. application Ser. No. 10,541,311 filed Jan. 24, 2006, the entire disclosure of which is incorporated herein by reference, and which is a national stage of PCT/EP2003/014313, filed Dec. 16, 2003, and claims priority of German patent application no. 103 00 298.7, filed Jan. 2, 2003.

**BACKGROUND AND SUMMARY OF THE
INVENTION**

The invention relates to an exhaust gas aftertreatment installation for the aftertreatment of an exhaust gas generated by a combustion device, in particular a motor vehicle internal combustion engine, having a nitrogen oxide storage catalytic converter and an SCR catalytic converter with the ability to store ammonia, which is arranged downstream of the nitrogen oxide storage catalytic converter or integrated with the latter in a common catalytic converter unit. The invention also relates to an exhaust gas aftertreatment method which can be carried out using an installation of this type. Installations and methods of this type are used in particular for the aftertreatment or purification of exhaust gases from internal combustion engines operated predominantly in lean-burn mode in motor vehicles.

The use of nitrogen oxide storage catalytic converters, also known as NO_x storage catalytic converters or NO_x absorber catalytic converters, or NSC for short, is generally known for lowering the levels of nitrogen oxides downstream of internal combustion engines operated in lean-burn mode. Lean operating phases of the internal combustion engine correspond to adsorption phases of the nitrogen oxide storage catalytic converter, in which the nitrogen oxide storage catalytic converter oxidizes nitrogen monoxide (NO) to form nitrogen dioxide (NO₂), which it temporarily stores in the form of nitrates. During brief, periodic regeneration or desorption phases, the stored nitrates are removed from the nitrogen oxide storage catalytic converter by the nitrates being converted into nitrogen dioxide and then nitrogen monoxide. The latter is then reduced to form nitrogen by suitable reducing agents.

One known technique used to provide the required reducing agents consists in switching the combustion device, which is operated predominantly in lean-burn mode and the exhaust-gas from which is being aftertreated, to rich-burn mode for a brief period of time, with the result that hydrogen (H₂), carbon monoxide (CO) and unburnt hydrocarbons (HC) are present in the exhaust gas as reducing agents. Various specific measures for controlling the air/fuel ratio, also known as the air ratio λ for short, have already been proposed for this purpose, cf. for example the laid-open specifications EP 0 560 991 A1 and DE 196 26 835 A1. The nitrogen oxide reduction may also take place in a downstream catalytic converter known as a deNO_x catalytic converter; it is also possible for hydrocarbons to be metered in downstream of the engine in order to provide the reducing agents, cf. for example the laid-open specifications EP 0 540 280 A1 and EP 0 573 672 A1.

A number of problem points need to be borne in mind during this alternating adsorption/desorption operation. For example, considerable quantities of the polluting gas ammonia (NH₃) may form through reaction of hydrogen with nitrogen monoxide and/or nitrogen dioxide may form in the regen-

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eration phase, depending on the catalytic converter temperature, the exhaust gas composition and the material composition of the nitrogen oxide storage catalytic converter. When switching from a lean exhaust gas atmosphere to a rich exhaust gas atmosphere, there is the risk of an undesirable breakthrough of nitrogen oxides on account of sudden decomposition of nitrates if suitable quantities of reducing agent are not provided quickly enough. When switching from a rich exhaust gas atmosphere to a lean exhaust gas atmosphere, the nitrogen oxide storage catalytic converter may be heated as a result of exothermic combustion reactions, with the result that nitrates which have already formed can be decomposed again and can predominantly no longer be stored, which can cause undesirable nitrogen oxide slippage. With this NO_x storage catalytic converter technology, efficient lowering of the levels of nitrogen oxides is restricted to a relatively narrow temperature range, approximately between 200° C. and 400° C., since at lower temperatures it is difficult to oxidize NO to form NO₂, and at higher temperatures the nitrates formed can no longer be stably stored in significant quantities, and the thermodynamic equilibrium between NO and NO₂ increasingly shifts toward nitrogen monoxide.

A further problem when using sulfur-containing fuels is what is known as sulfur poisoning of the NO_x storage catalytic converter as a result of the accumulation of sulfates, which are more stable than the nitrates and do not decompose during the NO_x regeneration phases. Therefore, special desulfating phases at elevated exhaust-gas temperature and with a rich exhaust gas composition are carried out from time to time in order to remove sulfates, cf. for example laid-open specification DE 198 27 195 A1. During desulfating, the polluting gas hydrogen sulfide (H₂S) may form; emission of this gas should be avoided. For this purpose, for example in patent DE 100 25 044 C1, it is proposed that secondary air be fed into the exhaust train during the desulfating phases, in order to oxidize the hydrogen sulfide in a downstream oxidation catalytic converter.

Another known exhaust gas aftertreatment method is the process known as selective catalytic reduction, or SCR for short. In this process, a selectively acting reducing agent, typically ammonia, is added to the exhaust gas in order to reduce nitrogen oxides. The ammonia is temporarily stored in a suitable deNO_x catalytic converter, also known as an SCR catalytic converter for short, and is used by the latter to catalytically reduce nitrogen oxides (NO_x) contained in the exhaust gas to form nitrogen and water. The effectiveness of SCR catalytic converters is highly dependent on the NO/NO₂ ratio at low temperatures, with a maximum efficiency at an NO₂ level of approx. 50% for temperatures below 200° C. and a greatly reduced efficiency if the NO₂ level is lower. At higher temperatures above approx. 400° C., the nitrogen oxide reduction is limited by oxidation of ammonia, and moreover the ammonia storage capacity of the SCR catalytic converter decreases as the temperature rises. The overall result for SCR systems of this type is that the temperature window which is suitable for efficiently lowering the levels of nitrogen oxides is from approximately 250° C. to approximately 550° C. SCR catalytic converters are subject to thermal aging and should not be exposed to temperatures of over approximately 700° C. to 750° C. At low temperatures, SCR catalytic converters may also temporarily store unburnt hydrocarbons, and even when the exhaust gas composition is rich, given a suitable design, they may oxidize hydrocarbons, in particular if they contain vanadium oxide (V₂O₅) as a catalytic material.

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To provide the ammonia in the exhaust gas, it is known to introduce urea, from which ammonia is formed through hydrolysis or thermolysis. One problem in this context, in particular for vehicle applications, is that a corresponding supply of urea has to be carried around. Therefore, as an alternative, internal generation of ammonia has already been proposed. For this purpose, it is proposed in laid-open specifications WO 97/17532 A1 and DE 199 49 046 A1 that an ammonia-generating catalytic converter and, downstream of the latter, an ammonia storage and nitrogen oxide reduction catalytic converter be provided, preferably with the addition of an oxygen storage catalytic converter between the two catalytic converters mentioned above or downstream of the ammonia storage catalytic converter and the nitrogen oxide reduction catalytic converter.

Laid-open specification EP 0 878 609 A1 has described an exhaust gas aftertreatment installation of the generic type, in which an NO_x storage catalytic converter and, downstream of the latter, an SCR catalytic converter are arranged in the exhaust train. As an alternative or in addition to a three-way catalytic converter, the NO_x storage catalytic converter can be designed to form ammonia when the engine is briefly operated under rich-burn conditions, which is realized by an after-injection of fuel into at least some of the engine combustion chambers. With this type of internal generation of ammonia, there is a risk of the quantity of ammonia which is generated exceeding the ammonia storage capacity of the SCR catalytic converter, resulting in undesirable ammonia slippage.

The exhaust gas aftertreatment measures described above do not lower the levels of particles, in particular of carbon particulates. It is known to use particulate filters to do this. Carbon particulates which have collected in the particulate filter can be burnt off at elevated temperature in the presence of oxygen. A standard measure for heating the particulate filter consists in introducing fuel into the exhaust gas, for example by an afterinjection, and burning this fuel in an oxidation catalytic converter connected upstream of the particulate filter. What are known as CRT systems with continuous particulate filter regeneration are also known, cf. for example U.S. Pat. No. 4,902,487. In these systems, nitrogen dioxide is formed from NO at the oxidation catalytic converter and oxidizes the carbon particulates which have collected in the particulate filter.

To lower the levels of particulate and nitrogen oxides, laid-open specification DE 199 21 974 A1 describes an exhaust gas aftertreatment installation having an oxidation catalytic converter, a downstream NO_x storage catalytic converter and a particulate filter downstream of the NO_x storage catalytic converter or between the oxidation catalytic converter and the NO_x storage catalytic converter. In the case of the former arrangement, the oxidation catalytic converter promotes the function of the NO_x storage catalytic converter through the formation of NO₂, but it is not possible to achieve a CRT effect for the particulate filter, since the nitrogen oxides are already being reduced to nitrogen upstream of the particulate filter. If the oxidation catalytic converter is used to heat the particulate filter by combustion of afterinjected fuel, this arrangement results in a high thermal loading of the NO_x storage catalytic converter and a relatively high fuel consumption. In the other arrangement described, the exhaust gas upstream of the NO_x storage catalytic converter predominantly contains NO and only a small amount of NO₂, since the latter is converted into NO by the CRT effect, with the result that the storage characteristics of the NO_x storage catalytic converter deteriorate. If the oxidation catalytic converter in this arrangement is used for desulfating-heating of the NO_x storage catalytic converter through combustion of afterin-

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jected fuel, the high heat capacity and the heat transfer in the intervening exhaust train section means that a relatively high temperature has to be reached at the oxidation catalytic converter, which can lead to thermal aging effects in the latter.

The invention is based on the technical problem of providing an exhaust gas aftertreatment installation of the type described in the introduction and an associated exhaust gas aftertreatment method with which as many of the following demands as possible can be satisfied to a high degree with relatively little outlay: effective reduction of nitrogen oxides in a wide temperature range, no need for an additional reducing agent operating medium, avoidance of ammonia and hydrogen sulfide emissions, minimal particulate emissions, particulate oxidation through NO₂ reaction, minimal CO and HC emissions, relatively low thermal loading of all the components used to purify the exhaust gas, minimal increased fuel consumption and a low demand for installation space.

The invention solves this problem by providing an exhaust gas aftertreatment installation for the aftertreatment of an exhaust gas generated by a combustion device, in particular a motor vehicle internal combustion engine, having a nitrogen oxide storage catalytic converter and an SCR catalytic converter with the ability to store ammonia, which is arranged downstream of the nitrogen oxide storage catalytic converter or integrated with the latter in a common catalytic converter unit.

The invention also solves this problem by providing a method for the aftertreatment of an exhaust gas generated by a combustion device, in particular a motor vehicle internal combustion engine, in which nitrogen oxides contained in the exhaust gas are temporarily stored in a nitrogen oxide storage catalytic converter during adsorption operating phases of the latter and are released again from the nitrogen oxide storage catalytic converter during regeneration operating phases of the latter, with ammonia being generated, and ammonia which is generated is temporarily stored in a downstream SCR catalytic converter and is used for nitrogen oxide reduction, characterized in that the recorded nitrogen oxide content of the exhaust gas downstream of the SCR catalytic converter and/or downstream of the nitrogen oxide storage catalytic converter and/or the ammonia loading of the SCR catalytic converter is used as a criterion for the instant at which a regeneration operating phase is triggered for the nitrogen oxide storage catalytic converter can further include the following step wherein nitrogen oxides contained in the exhaust gas are temporarily stored in a nitrogen oxide storage catalytic converter during adsorption operating phases of the latter and are released again from the nitrogen oxide storage catalytic converter during regeneration operating phases of the latter, with ammonia being generated, and ammonia which is generated is temporarily stored in a downstream SCR catalytic converter and is used for nitrogen oxide reduction, characterized in that a desired ammonia generation quantity which is to be generated during a current regeneration operating phase of the nitrogen oxide storage catalytic converter is determined, and the subsequent regeneration operating phase is carried out as a function of the desired ammonia generation quantity determined.

In addition to a nitrogen oxide storage catalytic converter and an SCR catalytic converter connected downstream of it, the exhaust gas aftertreatment installation additionally includes a particulate filter and/or an NO₂-producing catalytic converter arranged upstream of the SCR catalytic converter.

The nitrogen oxide storage catalytic converter allows the levels of nitrogen oxides to be effectively lowered, in particular even in the case of lean-burn internal combustion engines.

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By virtue of its NH_3 storage capacity, the downstream SCR catalytic converter prevents undesired emission of ammonia generated by the NO_x storage catalytic converter. At the same time, the SCR catalytic converter is able to use stored ammonia to reduce any nitrogen oxide which may still be present in the exhaust gas downstream of the NO_x storage catalytic converter, with the ammonia being oxidized at the same time. This effect can be exploited to deliberately form ammonia at the nitrogen oxide storage catalytic converter, in order for this ammonia to be used as reducing agent in the SCR catalytic converter. As a result, the effective lowering of the levels of nitrogen oxides can be maintained even during periods in which the temperature of the NO_x storage catalytic converter is temporarily outside its range in which it has a conversion activity, for example as a result of the exothermicity following a transition from a lean exhaust gas composition to a rich exhaust gas composition.

If nitrogen oxides are still present in the exhaust gas downstream of the NO_x storage catalytic converter, these nitrogen oxides are generally in the form of NO ; the NO_2 content is much lower, amounting, for example, to at most 20%. However, at low temperatures below 300°C ., the efficiency of the SCR catalytic converter is highest approximately at an NO_2 level of 50%, and significantly reduced where the NO_2 level is lower. To increase the efficiency of the SCR catalytic converter, the NO_2 -producing catalytic converter may be connected upstream of it. This catalytic converter may have a relatively small volume and may have a coating which, inter alia, contains a precious metal (e.g. platinum) and is able to increase the NO_2 level in the NO_x emission to at least approximately 50% at least in a temperature range from approximately 200°C . to 350°C . One particular feature of the coating of the NO_2 -producing catalytic converter is its property of deliberately not oxidizing ammonia which is generated in the NO_x storage catalytic converter when operating at $\lambda < 1$, but rather allowing this ammonia to pass through in unchanged form. This can be achieved, for example, by the coating not containing an oxygen-storing component.

In a corresponding control unit, which can also be used, for example, to control the combustion device, such as an internal combustion engine, it is preferable to implement functions which decide on the need for and feasibility of targeted generation of NH_3 and preset the operating parameters, in particular the duration and extent of enrichment during NSC regeneration, in a suitable way. The formation of NH_3 can typically be boosted by a lower air ratio and a longer regeneration time, provided that the temperature of the NO_x storage catalytic converter is in the range in which NH_3 formation is possible. Furthermore, operation of the combustion device during NSC regeneration can be set in a manner known per se such that high untreated NO_x emissions from the combustion device result, and as a result the formation of NH_3 at the NO_x storage catalytic converter is boosted further.

It has been found that the SCR catalytic converter can also be used to avoid H_2S emission, produced, for example, during desulfating. Tests have shown that an SCR catalytic converter, on account of its specific properties, can oxidize hydrogen sulfide formed during the desulfating to form SO_2 even at a rich exhaust gas composition ($\lambda < 1$). This makes it possible to avoid unpleasant odor pollution.

As a further particular feature, SCR catalytic converters, provided that they contain vanadium oxide, can even oxidize unburnt hydrocarbons (HC) during rich conditions ($\lambda < 1$). This makes it possible to reduce the extent to which reducing agent breaks through during NSC regeneration. In particular, by way of example, it is possible to lower the emission levels of possibly carcinogenic hydrocarbons, such as benzene,

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toluene, ethylbenzene and xylene, which can form under rich conditions at the NO_x storage catalytic converter. On account of its ability to store hydrocarbons even at low temperatures, the SCR catalytic converter can additionally make a contribution to lowering the levels of HC emissions following a cold start. The HC which have been stored at low temperatures are released again at higher temperatures and can be oxidized at the SCR catalytic converter or a downstream oxidation catalytic converter.

A particulate filter can be used for lowering the levels of particulates downstream of the engine. This particulate filter highly efficiently retains the particulates emitted. As is customary, the particulates which have collected can be burnt off at regular intervals by increasing the temperature to over 600°C . If the exhaust gas reaching the particulate filter contains NO_2 , particulate oxidation also takes place even in the temperature range between approximately 250°C . and 400°C . as a result of reaction with NO_2 (CRT effect). The particulate filter may generally be catalytically coated, in which case the coating may contain components such as a precious metal (e.g. platinum) and a washcoat.

The maximum thermal loading of the individual components can be adapted to the specific requirements by using a suitable arrangement of the components. Moreover, by using a suitable arrangement it is possible to ensure that the temperatures of the individual components are within a range which is expedient for the corresponding function when the vehicle is driving. The rich-burn operation which is required for the regeneration of the NO_x storage catalytic converter can be realized by engine-internal measures or additional introduction of reducing agent (e.g. fuel or hydrogen) downstream of the engine.

The heating of the NO_x storage catalytic converter for desulfating purposes and of the particulate filter for thermal regeneration purposes can be effected by engine-internal measures, including afterinjection of fuel. In addition to the deliberately increased exhaust gas temperature, incompletely burnt hydrocarbons which remain in the exhaust gas lead to additional exothermicity at a catalytic converter optionally arranged close to the engine, with the result that the exhaust gas temperature is increased further. In addition or as an alternative, it is also possible for reducing agent (e.g. fuel or hydrogen) to be supplied in the exhaust train directly upstream of the component(s) to be heated or upstream of an oxidation catalytic converter connected upstream of these components. This has the advantage that the heat losses involved in heating further upstream components and heat losses resulting from cooling in the exhaust pipe are reduced. This restricts the outlay on energy and therefore the increased fuel consumption for the heating to a minimum. A further advantage is that in this way further upstream components are not subjected to high exhaust gas temperatures, and consequently the thermal aging of these components can be restricted to a minimum. Moreover, this prevents further upstream components, e.g. an upstream NO_x storage catalytic converter, from leaving the temperature window required for high efficiency as a result of the heating.

In the case of a catalytically coated particulate filter, a further advantage is that the conversion of fuel, on account of the high heat capacity of the particulate filter, continues to be possible even, for example, after prolonged overrun phases of the internal combustion engine with a low exhaust gas temperature. By contrast, when using a conventional catalytic converter, there is a risk that, on account of the low heat capacity, the temperature will drop below the light-off temperature under comparable conditions, meaning that catalytic conversion of the hydrocarbons will no longer be possible. In

general terms, other heating methods are possible as an alternative to supplying reducing agent (e.g. hydrogen or fuel) upstream of a catalytic converter. These other methods are not expressly mentioned below but can be used instead of supplying reducing agent downstream of the engine. In this context, by way of example, mention may be made of an electrically heated catalytic converter, electrical heating of the particulate filter or the use of a burner as standard conventional measures.

The supply of reducing agent downstream of the engine and upstream of the NO_x storage catalytic converter can also be utilized to set rich conditions for NSC regeneration when the engine is operating with lean exhaust gas. This is preferably implemented when the engine is operating between $\lambda=1.0$ and $\lambda=1.2$, since otherwise the quantity of reducing agent to be supplied is too great. This results in the advantage that high untreated NO_x emission usually occurs in the range between $\lambda=1.0$ and $\lambda=1.2$, whereas the level of untreated NO_x emissions is considerably lower at air ratios of $\lambda<1$. Consequently, this method can be used to achieve a high level of NO_x emission and therefore extensive formation of NH₃ during NSC regeneration.

To avoid high emissions of CO and HC during NSC regeneration operations with $\lambda<1$, if necessary secondary air can be blown in ahead of a downstream oxidation catalytic converter. The secondary air can, for example, be provided by an electrically driven secondary air pump or a compressor or, in the case of supercharged engines can be removed downstream of the compressor.

It is possible to considerably reduce the overall space taken up by optionally combining or integrating two of the above-mentioned functionalities in one component, for example, by applying a catalytic coating to a particulate filter.

In further configurations, the exhaust gas aftertreatment installation contains one or more NO_x sensors downstream of the NO_x storage catalytic converter and/or the SCR catalytic converter, and/or means for recording the temperature of one or more of the exhaust gas purification components and/or means for recording the NH₃ loading of the SCR catalytic converter.

Various possible implementations are possible for the order in which the NO_x storage catalytic converter, SCR catalytic converter, particulate filter and NO₂-producing catalytic converter are arranged in the exhaust train, each of these implementations having specific properties and advantages; the options include multi-flow arrangements.

The basic method described above allows relatively accurate, model-based control of the time at which a regeneration of the nitrogen oxide storage catalytic converter is initiated.

The second method described above allows targeted control of the generation of ammonia during a respective regeneration phase of the nitrogen oxide storage catalytic converter taking account of the current conditions, in particular with regard to the temperatures of the ammonia-generating NO_x storage catalytic converter and of the SCR catalytic converter and/or the ammonia loading of the SCR catalytic converter; a variable quantity of ammonia which is to be generated during the current regeneration phase of the NO_x storage catalytic converter can be predetermined as a function of the operating state which has been ascertained.

In one configuration of this method, the results of the determination as to whether the exhaust gas air ratio downstream of the NO_x storage catalytic converter has dropped below a threshold value, which is dependent on the quantity of ammonia which it is desired to form, can be used as a criterion for terminating a regeneration phase of the NO_x storage catalytic converter.

In a further configuration of the method according to the invention, an external supply of reducing agent, e.g. downstream of the engine, into the exhaust train can be provided for during the NSC regeneration, in order for the combustion device also to be operated under lean-burn conditions during this period, resulting in high untreated NO_x emissions from the combustion device.

In a further configuration of the method, it is possible to provide for secondary air to be fed into the exhaust train at a suitable location during the rich-burn operating phases, in order to oxidize any NH₃, H₂S, CO and HC which may be present during these operating phases and thereby to prevent corresponding emissions of pollutants.

Advantageous embodiments of the invention are illustrated in the drawings and described below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a schematic block diagram illustration of an internal combustion engine of a motor vehicle with connected single-flow exhaust gas aftertreatment installation, which includes, connected in series, a first oxidation catalytic converter, a particulate filter, an NO_x storage catalytic converter, an NO₂-producing catalytic converter, an SCR catalytic converter and a second oxidation catalytic converter,

FIG. 2 shows a schematic block diagram illustration in accordance with FIG. 1, but with a modified exhaust gas aftertreatment installation which includes, connected in series, an NO_x storage catalytic converter, an NO₂-producing catalytic converter, a particulate filter, an SCR catalytic converter and an oxidation catalytic converter,

FIG. 3 shows a schematic block diagram illustration in accordance with FIG. 1, with a modified exhaust gas aftertreatment installation, which includes, connected in series, an NO_x storage catalytic converter, an NO₂-producing catalytic converter, an SCR catalytic converter, an oxidation catalytic converter and a particulate filter,

FIG. 4 shows a schematic block diagram illustration in accordance with FIG. 1, but with a modified exhaust gas aftertreatment installation, which includes a first oxidation catalytic converter, an integrated nitrogen oxide storage and SCR catalytic converter, a second oxidation catalytic converter and a particulate filter,

FIG. 5 shows a schematic block diagram illustration in accordance with FIG. 1, but for a modified internal combustion engine with a two-flow exhaust train and associated two-flow exhaust gas aftertreatment installation, and

FIG. 6 shows a schematic block diagram illustration in accordance with FIG. 2, but with an oxidation catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas.

DETAILED DESCRIPTION OF THE DRAWINGS

The exhaust gas aftertreatment installation illustrated in FIG. 1 includes, downstream of an internal combustion engine 1, as seen in the direction of flow of the exhaust gas, in an exhaust train 3, the following successive components: an oxidation catalytic converter 4, a particulate filter 5, an NO_x storage catalytic converter 6, an NO₂-producing catalytic converter 13, an SCR catalytic converter 7 and a further oxidation catalytic converter 4 as exhaust gas purification components. A control unit 2 is used to control the internal combustion engine 1, which may, for example, be a standard diesel or spark-ignition engine, and the exhaust gas aftertreatment installation. Furthermore, there are temperature sensors 8, NO_x sensors 9, lambda sensors 10, devices 11 for supplying

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reducing agent downstream of the engine, a device **12** for supplying secondary air and pressure sensors **14** provided at suitable locations in the exhaust train **3**, as shown.

The internal combustion engine **1** delivers exhaust gas containing, inter alia, NO_x particulates, CO and HC. During standard lean-burn operation of the internal combustion engine **1**, CO and HC are oxidized at the oxidation catalytic converter **4** to form CO₂ and H₂O. Moreover, some of the NO contained in the exhaust gas is oxidized to form NO₂. The particulates which are present in the exhaust gas are retained in the particulate filter **5**. Some of the carbon particulates which have collected in the particulate filter **5** are oxidized by reaction with NO₂, with NO₂ being reduced to NO. The nitrogen oxides contained in the exhaust gas are stored in the NO_x storage catalytic converter **6**. If nitrogen oxides are still present in the exhaust gas downstream of the NO_x storage catalytic converter **6**, these nitrogen oxides are generally in the form of NO; the NO₂ level is significantly lower, amounting, for example, to at most 20%. However, the efficiency of the SCR catalytic converter **7** at low temperatures below 300° C. is highest at an NO₂ level of approximately 50% and is significantly reduced if the level of NO₂ is lower. Therefore, the NO₂-producing catalytic converter **13** is connected upstream of the SCR catalytic converter **7**. This catalytic converter **13** has a coating which contains, inter alia, precious metal (e.g. platinum) and is able to increase the level of NO₂ in the total emission of NO_x to at least approximately 50%, at least in a temperature range from approximately 200° C. to 350° C. One particular feature of the coating of the NO₂-producing catalytic converter is its ability of deliberately not oxidizing ammonia generated in the NO_x storage catalytic converter during operation at $\lambda < 1$ but rather allowing this ammonia to pass through in unchanged form. This can be achieved, for example, by the coating not containing any oxygen-storing components. The SCR catalytic converter **7** is able to reduce the nitrogen oxide with the aid of NH₃ stored therein. In this case, the efficiency at temperatures below 300° C. is increased by the NO₂-producing catalytic converter **13** connected upstream.

Heating measures can be employed to ensure that sufficient temperatures are reached at all the components, in particular at the NO_x storage catalytic converter **6** and SCR catalytic converter **7**, even during low-load operation, and thereby to ensure optimum lowering of the levels of NO_x. These heating measures may be engine-internal, e.g. a shift towards the late position for the main injection or an afterinjection, or may take place downstream of the engine, as a result of reducing agent being supplied upstream of the NO_x storage catalytic converter, in order to generate exothermicity, provided that the NO_x storage catalytic converter **6** has reached a sufficient temperature to convert the reducing agent. Further measures for increasing the exhaust gas temperature may include, increasing the idling speed, lengthening the afterglow time, connecting up additional electrical consumers or increasing the EGR rate. The abovementioned heating measures can be controlled, for example, by the control unit **2** as a function of the incoming temperature sensor signals or by means of a model. The exhaust pipe **3** may be thermally insulated in order to minimize heat losses from the exhaust gas. By way of example, it is possible to use an air gap insulation.

NSC regenerations are required at regular intervals. The times for regeneration operations are determined with the aid of the NO_x sensor **9** downstream of the SCR catalytic converter. The signal from the NO_x sensor **9** is recorded and assessed in the control unit **2**. If the breakthrough of NO_x is unacceptably high, for example if it exceeds a certain proportion of the untreated NO_x emissions (e.g. NO_x content down-

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stream of NO_x storage catalytic converter >10% of the untreated NO_x emissions), the control unit **2** requests an NSC regeneration. If criteria which are taken into account in the control unit **2** and are a precondition on the engine side for an NSC regeneration to be realized are satisfied, for example, operation in a specific part of the operating range of the engine **1** in which NSC regeneration can be effected, the NSC regeneration is initiated.

Models for the untreated NO_x emission, the NO_x storage capacity of the NO_x storage catalytic converter **6**, the NH₃ formation at the NO_x storage catalytic converter and the NH₃ storage in the SCR catalytic converter **7** are stored in the control unit **2**. These models can be used to assess the NO_x sensor signal downstream of the SCR catalytic converter and can also be used for diagnostic purposes. The models can be adapted to the current state of aging of the catalytic converters on the basis of the sensor signals. Alternatively, the aging state can be diagnosed by comparing the sensor signals from the NO_x sensors **9** and/or the lambda sensors **10** with the modeled behavior of the catalytic converters, without, however, adapting the model.

As an alternative to considering the NO_x signal downstream of the SCR catalytic converter, or as an additional option, it is possible to request an NSC regeneration when the modeled SCR loading with NH₃ drops below a relative value, e.g. 5% of the possible NH₃ loading, or an absolute value, e.g. 0.1 g of NH₃.

As an alternative to considering the NO_x signal downstream of the SCR catalytic converter, it is also possible to consider the signal from the NO_x sensor **9** downstream of the NO_x storage catalytic converter. This can be assessed in a similar way to the procedure described above and can be used as a criterion to demand an NSC regeneration.

Alternatively the signal from the NO_x sensor **9** downstream of the NO_x storage catalytic converter can be used as an input variable for the NSC model in the control unit **2**. The nitrate loading of the NO₂ storage catalytic converter **6** can be calculated with the aid of the model, thereby allowing the NH₃ formation to be estimated taking the aging into account. Since the NH₃ loading of the SCR catalytic converter **7** is likewise calculated by means of a model, it is possible to request an NSC regeneration if the modeled SCR loading with NH₃ drops below a relative value, e.g. 5% of the possible NH₃ loading, or an absolute value, e.g. 0.1 g of NH₃.

In principle, it is also possible to use both NO_x sensors **9**, in which one sensor, as described above, delivers a criterion for requesting an NSC regeneration and the second NO_x sensor is used to diagnose and adapt the catalytic converter model in the control unit **2**. In addition, an NH₃ sensor (not shown in FIG. 1) can be provided downstream of the NO_x storage catalytic converter and also downstream of the SCR catalytic converter; the signal from this NH₃ sensor can be used to adapt the models of the NO_x storage catalytic converter **6** and the SCR catalytic converter **7** or to control the regeneration parameters.

The control unit **2** includes functions which decide upon the need for and feasibility of controlled generation of NH₃ during an impending NSC regeneration and predetermine the operating parameters, in particular the duration and degree of enrichment, accordingly. An important criterion in this respect is the temperatures of the NO_x storage catalytic converter **6** and of the SCR catalytic converter **7**. The temperatures are determined by the temperature sensors **8** in or downstream of the respective components. Alternatively, the temperature of the SCR catalytic converter **7** can be calculated on the basis of the measured temperature downstream of the NO_x storage catalytic converter, with the aid of a model in

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the control unit 2, so that there is no need for the sensor 8 downstream of the SCR catalytic converter. In addition to the temperatures of the NO_x storage catalytic converter 6 and of the SCR catalytic converter 7, it is also possible, for example, for the current NH₃ loading, calculated by model means, of the SCR catalytic converter 7 to be used as a criterion.

If the temperatures of the NO_x storage catalytic converter 6 and of the SCR catalytic converter 7 are within predetermined ranges, the current NH₃ loading of the SCR catalytic converter 7 is low and any further conditions are satisfied, maximum formation of NH₃ is desired. If the temperature of the NO_x storage catalytic converter 6 is outside the predetermined range, which may, for example, be between 230° C. and 370° C., formation of NH₃ is not possible or is only possible to a limited extent and is therefore also not aimed for. This avoids unnecessarily increased fuel consumption and high levels of HC and CO emissions on account of the regeneration lasting too long. If the temperature of the SCR catalytic converter 7 is outside the predetermined range, which may, for example, be between 200° C. and 450° C., formation of NH₃ is likewise not aimed for, or only a small amount is aimed for, since either NH₃ cannot be sufficiently stored in the SCR catalytic converter 7 and therefore would be emitted or conversion of NO_x at the SCR catalytic converter 7 is scarcely possible. The same applies to the situation in which the current NH₃ loading of the SCR catalytic converter 7 is so high that it is impossible for further NH₃ to form.

In general, in addition to the current temperatures, in particular in the case of the SCR catalytic converter 7, it is also possible to take account of temperature gradients, e.g. a rapid rise, and/or to implement a temperature prediction. The predicted temperature is then taken into account in addition to the current temperature. By way of example, reduced formation of NH₃ is aimed for if a strong increase in the temperature of the SCR catalytic converter 7 is predicted, since otherwise there is a risk of subsequent NH₃ desorption in the SCR catalytic converter 7. The state of aging of the NO_x storage catalytic converter 6 is likewise taken into account when deciding on the formation of NH₃ which is aimed for, since the reduction of NO_x in the SCR catalytic converter 7 becomes increasingly important with progressive aging of the NO_x storage catalytic converter 7.

The optimum air ratio is defined in the control unit 2 as a function of the NH₃ which is aimed for. If it is aimed to form high levels of NH₃ an air ratio for maximum formation of NH₃ is preset. If this is not the case, an air ratio for the formation of small amounts or no NH₃ is preset. Intermediate values for the formation of medium amounts of NH₃ are also possible. The air ratio can also be varied continuously or in steps during the NSC regeneration as a function of the temperatures of NO_x storage catalytic converter 6 and SCR catalytic converter 7 and further parameters. By way of example, a lower air ratio can be set at the start and a higher air ratio can be set as regeneration progresses, in order to form high levels of NH₃ combined, at the same time, with low emissions of HC and CO during the NSC generation.

The duration of the NSC regenerations is likewise set as a function of the desired formation of NH₃. The gradual drop in the air ratio downstream of the NO_x storage catalytic converter 6 to values of lower than $\lambda=1$ is used to this end as a criterion for terminating the NSC regeneration. If it is aimed to form high levels of NH₃, the regeneration is terminated as soon as the air ratio determined by the lambda sensor 10 downstream of the NO_x storage catalytic converter drops below a threshold value λ_1 . It is optionally also possible to continue a predetermined time or number of working cycles of the engine 1 beyond this point. If the aim is for no NH₃ to

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be formed, the regeneration is terminated immediately as soon as the air ratio downstream of the NO_x storage catalytic converter drops below a threshold value λ_2 , where λ_2 is greater than λ_1 . As a result, breakthroughs of HC/CO are substantially avoided and a low increased fuel consumption is achieved. The threshold values can be varied as a function of the NSC aging and further parameters. Intermediate values are also possible in order to achieve the formation of a medium level of NH₃.

As soon as the aim is to form high levels of NH₃, operation of the engine during NSC regeneration is additionally set in such a way that the untreated NO_x emissions from the engine 1 are as high as possible. This can be effected in combination with a supply of reducing agent downstream of the engine and upstream of the NO_x storage catalytic converter 6. This further boosts the formation of NH₃ at the NO_x storage catalytic converter 6. If the aim is for no NH₃ formation, by contrast, the engine operation is set in such a way that the untreated NO_x emissions from the engine are as low as possible.

The device 11 arranged upstream of the NO_x storage catalytic converter 6 for supplying reducing agent downstream of the engine is used to heat up the NO_x storage catalytic converter 6 for a desulfating operation. This measure is carried out in addition to measures taken at the engine for heating. The boost provided by the supply of reducing agent downstream of the engine makes it possible to reduce the extent of the measures taken at the engine, so that the thermal aging of the oxidation catalytic converter is reduced. Heating of the NO_x storage catalytic converter 6 exclusively by supplying reducing agent downstream of the engine is not desirable, since the large quantity of reducing agent would generate considerable exothermicity at the NO_x storage catalytic converter 6, which would lead to thermal aging. The quantity of reducing agent supplied is controlled, inter alia, as a function of the following parameters: the desired temperature of the NO_x storage catalytic converter 6, the actual temperature downstream of the particulate filter, the actual temperature downstream of the NO_x storage catalytic converter and the mass flow of exhaust gas.

Furthermore, at least one of the two devices illustrated in FIG. 1 for supplying reducing agent downstream of the engine can be used to maximize the untreated NO_x emissions from the engine 1 during the NSC regeneration. For this purpose, the engine 1 is operated with an air ratio $\lambda>1$ at which a high NO_x emission level is reached, preferably between $\lambda=1.0$ and $\lambda=1.2$. The supply of reducing agent downstream of the engine allows the air ratio upstream of the NO_x storage catalytic converter to be lowered to $\lambda<1$.

Thermal regenerations of the particulate filter 5 are required at regular intervals. This may be the case, for example, if a high pressure drop at the particulate filter 5 is recorded by the pressure sensors 14 upstream and downstream of the particulate filter, implying unacceptably high loading of the particulate filter 5. The device 11 for supplying reducing agent downstream of the engine which is arranged upstream of the particulate filter 5 and the oxidation catalytic converter 4 connected upstream of the particulate filter 5 can be used to heat the particulate filter 5. This measure is carried out in addition to engine-internal measures for raising the exhaust gas temperature. The boost provided by the supply of reducing agent downstream of the engine makes it possible to reduce the extent of engine-internal measures. It is not desirable for the oxidation catalytic converter 4 and therefore the particulate filter 5 to be heated exclusively by supplying reducing agent downstream of the engine, since the large quantity of reducing agent would generate extensive exothermicity at the oxidation catalytic converter 4, which would

The particulate filter **5** may be catalytically coated. The catalytic coating of the particulate filter **5** may be similar to the coating of one of the oxidation catalytic converters **4**. As a result, the upstream oxidation catalytic converter **4** can be made smaller or provided with a lower precious metal content, which leads to space and/or cost benefits. If appropriate, the oxidation catalytic converter **4** connected upstream of the particulate filter **5** can also be dispensed with altogether. In this case, the temperature sensor **8** upstream of the particulate filter **5** is likewise removed. Therefore, it is no longer the temperature upstream of the particulate filter, but rather the temperature downstream of the particulate filter which is used as control variable when heating the particulate filter **5** for thermal regeneration. However, the catalytic coating of the particulate filter **5** may also be similar to the coating of the NO_x storage catalytic converter **6**. This allows the downstream NO_x storage catalytic converter **6** to be of smaller design, which leads to space and/or cost benefits. If appropriate,

In the arrangement shown in FIG. 2, once again, the device 11 for supplying reducing agent downstream of the engine, which is in this case positioned directly upstream of the NO₂-producing catalytic converter 13, can be used to heat the particulate filter 5, making it possible to reduce the extent of engine-internal measures required for this purpose, thereby reducing aging effects in the NO_x storage catalytic converter 6. It is not desirable to heat the NO₂-producing catalytic

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converter **13** purely by the supply of reducing agent downstream of the engine, on account of thermal aging effects in this catalytic converter. The quantity of reducing agent supplied is controlled inter alia as a function of the following parameters: the desired temperature of the particulate filter **5**, the actual temperature upstream of the NO_x-producing catalytic converter and downstream of the NO_x storage catalytic converter, the actual temperature downstream of the particulate filter and the mass flow of exhaust gas.

An advantage of the exemplary embodiment shown in FIG. **2** is that the NO_x storage catalytic converter **6**, on account of being positioned close to the engine, reaches the required operating temperature soon after a cold start. This means that few measures are required to erase the exhaust gas temperature. This reduces the increased fuel consumption resulting from heating measures. Furthermore, in this exemplary embodiment, the SCR catalytic converter **7** is protected from high temperatures during the desulfating of the NO_x storage catalytic converter **6**, since the length of the exhaust pipe results in considerable cooling of the exhaust gas by the time it reaches the SCR catalytic converter **7**, and in addition, the particulate filter **5** and the NO₂-producing catalytic converter **13** act as heat sinks. In this way, the thermal aging of the SCR catalytic converter **7** can be kept at a low level. As a further advantage, the high heat capacity of the particulate filter **5** leads to stabilization of the temperature of the downstream SCR catalytic converter **7** even when the vehicle driving operation is not in a steady state. This ensures that the SCR catalytic converter **7** is generally in a suitable temperature range, and therefore works with a high level of efficiency, even when the vehicle driving operation is not in a steady state. In addition, the risk of undesirable desorption of stored NH₃ at the SCR catalytic converter **7** as a result of a rapid increase in temperature is minimized.

The particulate filter **5** may be catalytically coated. The catalytic coating of the particulate filter **5** may be similar to the coating of the NO₂-producing catalytic converter **13**. As a result, the upstream NO₂-producing catalytic converter **13** can be made smaller or given a lower precious metal content, which leads to space and/or cost benefits. If appropriate, it is also possible for the NO₂-producing catalytic converter connected upstream of the particulate filter **5** to be dispensed with altogether.

However, the catalytic coating of the particulate filter **5** may also be similar to the coating of the NO_x storage catalytic converter **6**. This allows the NO_x storage catalytic converter **6** arranged close to the engine to be of smaller design, which leads to space and/or cost benefits. If appropriate, it is also possible for the separate NO_x storage catalytic converter **6** to be dispensed with altogether, i.e. for its function to be integrated in the particulate filter **5**. In this case, it is also possible for both the NO₂-producing catalytic converter **13** and the device **11** for supplying reducing agent downstream of the engine and upstream of the NO₂-producing catalytic converter **13** to be dispensed with. However, the pressure sensor **14** illustrated upstream of the particulate filter is retained, and the NO_x sensor **9**, illustrated downstream of the NO_x storage catalytic converter **6** in FIG. **2**, and the lambda sensor **10** are then positioned downstream of the particulate filter **5**.

Furthermore, the catalytic coating may also be similar to the coating of the downstream SCR catalytic converter **7**. This allows the SCR catalytic converter **7** to be of smaller design, which leads to space and/or cost benefits. If appropriate, the SCR catalytic converter as a separate component can also be dispensed with altogether. In this case, the temperature sensor **8** illustrated in FIG. **2** between particulate filter and SCR

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catalytic converter can be dispensed with, but the pressure sensor **14** illustrated downstream of the particulate filter is retained.

Instead of being arranged upstream of the particulate filter **5**, the NO₂-producing catalytic converter **13** may also be integrated at the outlet end of the NO_x storage catalytic converter **6**. Alternatively, the NO₂-producing catalytic converter **13** may also be arranged upstream of the SCR catalytic converter **7**. As a further possible option, it is also possible for the NO₂-producing catalytic converter **13** to be integrated at the inlet end of the SCR catalytic converter **7**. Alternatively, the NO₂-producing catalytic converter **13** can also be dispensed with altogether.

As illustrated in FIG. **6**, it is additionally possible for a further oxidation catalytic converter **4** to be connected upstream of the NO_x storage catalytic converter **6**, which can further lower the emissions of HC and CO in particular during a cold start.

As a further variant, FIG. **3** shows an exhaust gas aftertreatment installation which differs from that shown in FIG. **2** by virtue of the fact that the positions of particulate filter **5** and SCR catalytic converter **7** are switched, and the oxidation catalytic converter **4** is connected directly upstream of the particulate filter **5**. Moreover, the other components, i.e. the various sensors **8**, **9**, **10**, **14**, the devices **11** for supplying reducing agent downstream of the engine and the secondary air feed device **12** are arranged at modified positions suitably matched to the associated exhaust gas purification components **4** to **7**, **13** in the exhaust train **3**, in the same way as was the case in the example shown in FIG. **2** with respect to that shown in FIG. **1**. As in the exemplary embodiment explained above with reference to FIG. **2**, the following text will deal only with those measures and resulting effects of the example shown in FIG. **3** which differ from those of the examples shown in FIGS. **1** and **2**, while otherwise reference can be made, in connection with the corresponding functions and properties to the statements made above in connection with the examples illustrated in FIGS. **1** and **2**.

The NO₂-producing catalytic converter **13**, which in the example shown in FIG. **3** is connected directly upstream of the SCR catalytic converter **7**, once again allows the efficiency of the SCR catalytic converter **7** to be noticeably increased, in particular in the temperature range below 300° C.

In this case, the device **11** for supplying reducing agent downstream of the engine which is connected upstream of the oxidation catalytic converter **4** before the particulate filter **5** can be used to heat the particulate filter **5**. In this arrangement, the NO_x storage catalytic converter **6** and the SCR catalytic converter **7** are not thermally loaded by this measure. Heating of the particulate filter exclusively by the supply of reducing agent downstream of the engine is not desirable, in order not to cause excessive thermal aging of the oxidation catalytic converter **4**. The quantity of reducing agent supplied is controlled, inter alia, as a function of the following parameters: the desired temperature of the particulate filter **5**, the actual exhaust gas temperature upstream of the oxidation catalytic converter **4** or downstream of SCR catalytic converter **7**, the actual exhaust gas temperature downstream of the particulate filter **5** and the mass flow of exhaust gas.

An advantage of the example shown in FIG. **3** is that in addition to the NO_x storage catalytic converter **6**, the SCR catalytic converter **7**, by virtue of its position downstream of the NO_x storage catalytic converter **6**, reaches the required operating temperature relatively quickly after a cold start. A further advantage is that there is no need for an additional oxidation catalytic converter as a final component of the

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system in order to oxidize the undesirable exhaust gas components by blowing in secondary air. Moreover, in this exemplary embodiment the SCR catalytic converter 7 is protected from high temperatures during the thermal regeneration of the particulate filter 5, since it is positioned upstream of the particulate filter 5.

The particulate filter **5** may be catalytically coated, in which case the catalytic coating may be similar to that of the upstream oxidation catalytic converter **4**, so that the latter can be made smaller or given a lower precious metal content, which leads to space and/or cost benefits. It is optionally also possible for the oxidation catalytic converter connected upstream of the particulate filter **5** to be dispensed with altogether.

The NO₂-producing catalytic converter **13** may, as shown in FIG. **3**, be designed as a separate component. Alternatively, it may be integrated into the relevant component at the outlet end of the NO_x storage catalytic converter **6** or at the inlet end of the SCR catalytic converter **7** or may be dispensed with altogether. In an embodiment which is not illustrated, it is possible for a further oxidation catalytic converter to be connected upstream of the NO_x storage catalytic converter **6**, which can further reduce the HC and CO emissions in particular during a cold start.

FIG. 4 shows a further variant, in which the exhaust gas aftertreatment installation has a combined SCR and nitrogen oxide storage catalytic converter **15**, which combines the functions of the NO_x storage catalytic converter **6** and the SCR catalytic converter **7** from the examples shown in FIGS. **1** to **3**. An oxidation catalytic converter **4** is connected directly upstream of both this integrated catalytic converter **15** and the downstream particulate filter **5**. The other components in accordance with the examples shown in FIG. **1** to **3** have been arranged suitably for the positioning of these exhaust gas purification components **4**, **5**, **15**, as shown.

The integrated catalytic converter **15** can be realized, for example, by using an SCR catalytic converter which is produced as an unsupported extrudate, with the catalytic material of the SCR catalytic converter serving as a support for a further catalytic coating, specifically a nitrogen oxide storage catalyst coating. Alternatively, it is also possible, in the case of an SCR catalytic converter which is not produced as an unsupported extrudate, to apply a nitrogen oxide storage catalyst coating in addition to the SCR coating. In any case, it is advantageous that this measure considerably reduces the space required. Moreover, both functional components reach the required operating temperature very soon after a cold start, which means that scarcely any additional heating measures, which would increase the fuel consumption, are required.

During standard lean-burn operation of the internal combustion engine **1**, CO and HC are oxidized at the oxidation catalytic converter **4** close to the engine, to form CO₂ and H₂O. A significant proportion of the nitrogen oxide contained in the exhaust gas is temporarily stored in the integrated nitrogen oxide storage and SCR catalytic converter **15**, while the remainder is reduced by ammonia which is temporarily stored therein.

In the example shown in FIG. 4, the times of NSC regenerations are determined with the aid of the NO_x sensor 9 downstream of the integrated, combined catalytic converter 15, or alternatively by one of the other methods described above. In this case, the models stored in the control unit 2 comprise a model relating to the nitrogen oxide storage properties, the ammonia storage properties and the ammonia generation properties of the combined catalytic converter 15.

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In the example shown in FIG. 4, the temperature of the combined catalytic converter **15**, which can be recorded by the downstream temperature sensor **8**, is an important criterion for the operating parameters of an impending NSC regeneration and targeted generation of ammonia. In addition, it is also possible, for example, for the current ammonia loading, determined on the basis of a model, of the combined catalytic converter **15** to be used as a further criterion. Maximum formation of NH_3 may be aimed for, for example, if the temperature of the combined catalytic converter **15** is within a predetermined range of, for example, between 230° C. and 370° C. and the current NH_3 loading of the combined catalytic converter **15** is low, and also any further conditions are satisfied.

15 The device **11** for supplying reducing agent downstream of the engine which is arranged upstream of the oxidation catalytic converter **4** close to the engine can be used to heat the integrated, combined catalytic converter **15** for the purpose of desulfating of the nitrogen oxide storage catalyst coating, 20 with the support of additional engine heating measures, as explained above. The quantity of reducing agent supplied is controlled, inter alia, as a function of the following parameters: the desired temperature of the combined catalytic converter **15**, the actual temperature of the combined catalytic 25 converter **15** and the mass flow of exhaust gas.

The oxidation catalytic converter **4** connected upstream of the particulate filter **5** and the device **11** for supplying reducing agent downstream of the engine which is connected upstream of this oxidation catalytic converter **4** can be used to heat the particulate filter. In this arrangement, the combined nitrogen oxide storage and SCR catalytic converter **15** once again remains free of the thermal loading caused by the particulate filter heating. The quantity of reducing agent supplied is controlled, inter alia, as a function of the following parameters: the desired temperature of the particulate filter **5**, the actual exhaust gas temperature upstream of the oxidation catalytic converter **4**, the actual exhaust gas temperature downstream of the particulate filter **5** and the mass flow of exhaust gas.

It is advantageous in the exemplary embodiment shown in FIG. 4 that the combined nitrogen oxide storage and SCR catalytic converter 15 is protected from high temperatures during the thermal regeneration of the particulate filter 5 and there is no need for an additional oxidation catalytic converter as a final exhaust gas purification system component for oxidizing the undesirable exhaust gas components when secondary air is blown in. The particulate filter 5 may be catalytically coated, in particular with a catalytic coating similar to that of the upstream oxidation catalytic converter 4. In this case the upstream oxidation catalytic converter 4 can be designed to be smaller or with a lower precious metal content, which leads to corresponding space and/or cost benefits. It is optionally also possible for the oxidation catalytic converter 4 connected upstream of the particulate filter 5 to be dispensed with altogether.

The SCR catalyst coating and the nitrogen oxide storage catalyst coating can be applied to a support in suitably mixed form in the combined catalytic converter 15. Alternatively, it is possible for the two coatings to be applied alternately in the direction of flow of the exhaust gas, so that the exhaust gas firstly flows through a region comprising nitrogen oxide storage catalyst coating, then a region comprising SCR catalyst coating, then another region comprising nitrogen oxide storage catalyst coating, etc. This embodiment can also be realized by alternately arranging disks of a nitrogen oxide storage catalytic converter and disks of an SCR catalytic converter in series in a housing. The repeatedly alternating arrangement in

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the direction of flow of the exhaust gas has the advantage over a mixed combination of the two catalyst materials of resulting in a wider temperature window in which the system operates efficiently. For example, temperature peaks in the front region of the system have a less pronounced effect, for example during the formation of ammonia, if nitrogen oxide storage catalytic converter and SCR catalytic converter are in a repeatedly alternating arrangement than if an arrangement comprising a nitrogen oxide storage catalytic converter and a separate, downstream SCR catalytic converter is used.

FIG. 5 shows an exemplary embodiment in which the internal combustion engine 1 has a two-flow section of the exhaust train 3, with a suitably assigned exhaust gas after-treatment installation. The latter comprises an NO_x storage catalytic converter 6, an NO₂-producing catalytic converter 13 and an SCR catalytic converter 7, as well as associated sensor means 8, 9, 10 and device 11 for supplying reducing agent downstream of the engine, at suitable positions in accordance with the examples shown in FIGS. 1 to 4, arranged identically and symmetrically in each of the two parallel exhaust train sections. The two parallel exhaust trains are combined downstream of the two SCR catalytic converters 7 to form a subsequent single exhaust train section, in which the particulate filter 5, as well as an oxidation catalytic converter 4 connected directly upstream of it and suitable sensor means 8, 9, 14, device 11 for supplying reducing agent downstream of the engine and device 12 for supplying secondary air, are arranged, as shown.

A two-flow arrangement of this type may be appropriate, for example, for engines whereof the cylinders are in a V arrangement. It is a required condition that if exhaust gas turbo-charging is being used, a separate turbocharger be employed for each cylinder bank, since otherwise the two flows have to be combined upstream of the turbine of the turbocharger. The operating strategy for this exhaust gas aftertreatment system is such that only minor modifications are required compared to the operating mode of a single-flow system. This is important, since otherwise expensive new development of additional functions would be required in the control unit 2 of the internal combustion engine 1. Moreover, this approach allows the number of sensors used, and therefore the increased costs for the system as a whole, to be limited. The basic concept is for the two parallel trains to be considered as a single train, so that in principle the same operations take place in both trains. This is only possible if the two trains do not fundamentally differ with regard to untreated engine emissions, catalytic converter types and catalytic converter volumes, etc. More complex approaches, such as for example trains which are operated completely independently of one another and also, for example, time-offset phases of rich exhaust gas, so that lean exhaust gas is always present downstream of the point where the two trains are combined, are alternative options.

The operating mode of this two-flow system substantially corresponds to that of the single-flow system illustrated in FIG. 3, in which the exhaust gas purification components 4 to 7 and 13 are arranged in the same order, and consequently in this respect, reference can be made to the explanations given above in the example shown in FIG. 3. The corresponding processes in each case take place independently and in parallel in the two parallel exhaust train sections. A simple functional structure can be maintained for the control unit 2 by virtue of the fact that in the stored model the fundamentally identical catalytic converters 6 and 7, which are in each case arranged in parallel, of the two parallel exhaust train sections are in each case combined to form a single catalytic converter of double the volume. In one advantageous realization, if

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differences are detected between the two train sections with regard to the demand for NSC regeneration, it is possible to provide for an NSC regeneration to be initiated even if NO_x emissions which exceed the predetermined threshold value are detected at only one of the two NO_x storage catalytic converters **6**. Alternatively, the signals from the NO_x sensors **9** downstream of the NO_x storage catalytic converters **6** can be used in averaged or other weighted form as a representative nitrogen oxide concentration downstream of the NO_x storage catalytic converter for the NSC model in the control unit **2**.

When the aim is for high levels of ammonia to be formed, one of the two lambda sensors **10** downstream of the two parallel NO_x storage catalytic converters **6** measuring a value below the associated threshold value λ_1 can be used as a criterion for terminating NSC regenerations. If the aim is for no ammonia to be formed, the NSC regeneration is, for example, terminated as soon as the air ratio downstream of one of the two parallel NO_x storage catalytic converters **6** drops below the threshold value λ_2 .

An advantage of the exemplary embodiment shown in FIG. 5 is that, despite the geometry of the exhaust system differing significantly, the operating strategy remains similar to that used for the single-flow system shown in FIG. 3, and the properties and effects explained above in connection with this single-flow system are achieved in the same way, without any significant additional functions having to be provided for the control unit 2.

As an alternative to the example shown, it is also possible for the two parallel exhaust train sections to be combined to form a subsequent single-flow train section immediately downstream of the two parallel NO_x storage catalytic converters **6**; in this case, there is then only one SCR catalytic converter **7** with upstream optional NO_2 -producing catalytic converter **13**, located in this single-flow train section. In further alternative embodiments, it is possible to use integrated nitrogen oxide storage and SCR catalytic converters in each of the plurality of train sections, in accordance with the example shown in FIG. 4, and/or to use a different order of the exhaust gas purification components, in particular in accordance with FIGS. 1, 2 and 4.

Whereas the exemplary embodiments shown refer to an internal combustion engine of a motor vehicle, it will be understood that the exhaust gas aftertreatment installation according to the invention and the exhaust gas aftertreatment method according to the invention, as illustrated and explained above with reference to the examples shown, can also be used for other, for example stationary combustion devices which generate an exhaust gas which needs to be purified.

What is claimed is:

1. An installation for aftertreatment of exhaust gas generated by a diesel engine of a motor vehicle, said installation comprising:

a nitrogen oxide storage catalytic converter configured for temporarily storing nitrogen oxides contained in the exhaust gas during adsorption operating phases with a lean exhaust gas air ratio and, releasing and reducing stored nitrogen oxides during regeneration operating phases with a rich exhaust gas air ratio;

an SCR catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter, said SCR catalytic converter being configured to receive and store ammonia generated by the nitrogen oxide storage catalytic converter, and to reduce nitrogen oxides in the exhaust gas with the stored ammonia;

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a particulate filter arranged upstream of the SCR catalytic converter and downstream of the nitrogen oxide storage catalytic converter; and

an oxidation catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas.

2. The installation according to claim 1, wherein said particulate filter has a catalytic coating.

3. The installation according to claim 1, further comprising an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.

4. The installation according to claim 1, further comprising a reducing agent supplying device configured to feed fuel into the exhaust gas stream, as a reducing agent.

5. The installation according to claim 4, wherein said reducing agent supplying device is configured to feed fuel into the exhaust gas stream upstream of the particulate filter.

6. The installation according to claim 1, wherein said oxidation catalytic converter is arranged close to the engine.

7. The installation according to claim 1, further comprising means for recording the NO_x content in the exhaust gas downstream of the nitrogen oxide storage catalytic converter and/or downstream of the SCR catalytic converter.

8. The installation according to claim 1, further comprising a lambda sensor arranged between the nitrogen oxide storage catalytic converter and the particulate filter.

9. An exhaust gas aftertreatment method for purifying an exhaust gas of a diesel engine of a motor vehicle, said method comprising:

temporarily storing nitrogen oxides contained in the exhaust in a nitrogen oxide storage catalytic converter during adsorption operating phases;

releasing stored nitrogen oxides from the nitrogen oxide storage catalytic converter during regeneration operation phases, and thereby generating ammonia;

temporarily storing generated ammonia in an SCR catalytic converter arranged downstream of the nitrogen oxide storage catalytic converter;

using the stored for nitrogen oxide reduction in the SCR catalytic converter;

operating the combustion device under lean-burn conditions of the engine during adsorption operating phases;

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during lean-burn conditions of the engine oxidizing carbon monoxide and hydrocarbons contained in the exhaust gas in an oxidizing catalytic converter arranged as a first exhaust gas aftertreatment component, as seen in the direction of flow of the exhaust gas; and operating the combustion device under rich-burn conditions during regeneration operating phases.

10. The method according to claim 9, further comprising filtering out particulates in the exhaust gas with a particulate filter arranged downstream of the nitrogen oxide storage catalytic converter and guiding filtered exhaust gas to the SCR catalytic converter.

11. The method according to claim 9, further comprising determining an exhaust air ratio downstream of the nitrogen oxide storage catalytic converter and terminating a regeneration operation phase if the determined exhaust air ratio drops below a threshold value.

12. The method according to claim 9, further comprising shifting a main fuel injection and/or an afterinjection of the engine towards a late position for enhancing an exhaust gas temperature.

13. The method according to claim 9, further comprising performing from time to time a desulfation of the nitrogen oxide storage catalytic converter.

14. The method according to claim 13, wherein an afterinjection of fuel is performed during the desulfation phases.

15. The method according to claim 13, wherein hydrogen sulphide formed during the desulfation phases is oxidized by the SCR catalytic converter.

16. The method according to claim 10, further comprising performing from time to time a regeneration of the particulate filter.

17. The method according to claim 16, wherein an afterinjection of fuel is performed during the regeneration phases.

18. The method according to claim 9, further comprising enhancing an NO₂-ratio of the nitrogen oxides in the exhaust gas by means of a catalytic oxidation with an NO₂ producing catalytic converter disposed upstream of the SCR catalytic converter.

19. The installation according to claim 1, further comprising an additional oxidation catalytic converter arranged downstream of the SCR catalytic converter.

* * * * *

ADDENDUM 4

U.S. Patent Application No. 12/706,558

JA0104-128

OK TO ENTER: /T.V./

TITLE OF THE INVENTION

Catalyst System for the Reduction of NO_x and NH₃ Emissions

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. Application Serial No. 12/325,787 filed December 1, 2008, which is a continuation of U.S. Application Serial No. 11/684,064 filed March 9, 2007, now U.S. Patent No. 7,485,273 which is a continuation of U.S. Application Serial No. 10/065,470, filed October 22, 2002, now U.S. Patent No. 7,332,135.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The present invention is directed to a catalyst system to facilitate the reduction of nitrogen oxides (NO_x) and ammonia from an exhaust gas. More particularly, the catalyst system of this invention includes a lean NO_x trap in combination with an ammonia selective catalytic reduction (NH₃-SCR) catalyst, which stores the ammonia formed in the lean NO_x trap during rich air/fuel operation and then reacts the stored ammonia with nitrogen oxides to improve NO_x conversion to nitrogen when the engine is operated under lean air/fuel ratios. In an alternate embodiment, a three-way catalyst is designed to produce desirable NH₃ emissions at stoichiometric conditions and thus reduce NO_x and NH₃ emissions.

2. Background Art

[0003] Catalysts have long been used in the exhaust systems of automotive vehicles to convert carbon monoxide, hydrocarbons, and nitrogen oxides (NO_x) produced during engine operation into non-polluting gases such as carbon dioxide, water and nitrogen. As a result of increasingly stringent fuel economy and emissions standards for car and truck applications, it is preferable to operate an engine under lean conditions to improve vehicle

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GANDHI EXHIBIT 1025
Bandl-Konrad v. Gandhi
Interference No. 105,839

Serial No. 12/706,558
Atty Dkt: 3195-107
Clean Specification

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fuel efficiency and lower CO₂ emissions. Lean conditions have air/fuel ratios greater than the stoichiometric ratio (an air/fuel ratio of 14.6), typically air/fuel ratios greater than 15. While lean operation improves fuel economy, operating under lean conditions increases the difficulty in treating some polluting gases, especially NO_x.

[0004] Regarding NO_x reduction for diesel and lean burn gasoline engines in particular, lean NO_x adsorber (trap) technologies have been widely used to reduce exhaust gas NO_x emissions. Lean NO_x adsorbers operate in a cyclic fashion of lean and rich durations. The lean NO_x trap functions by adsorbing NO_x when the engine is running under lean conditions-until the NO_x trap reaches the effective storage limit-followed by NO_x reduction when the engine is running under rich conditions. Alternatively, NO_x reduction can proceed by simply injecting into the exhaust a sufficient amount of reductant that is independent of the engine operation. During this rich cycle, a short rich pulse of reductants, carbon monoxide, hydrogen and hydrocarbons reduces the NO_x adsorbed by the trap during the lean cycle. The reduction caused during the rich cycle purges the lean NO_x adsorber, and the lean NO_x adsorber is then immediately available for the next lean NO_x storage/rich NO_x reduction cycle. In general, poor NO_x reduction is observed if the air excess ratio λ is above 1. NO_x reduction generally increases over lean NO_x adsorbers as the λ ratio is decreased lower than 1. This air excess or lambda ratio is defined as the actual air/fuel ratio divided by the stoichiometric air/fuel ratio of the fuel used. The use of lean NO_x adsorber (trap) technology, and in particular the rich pulse of reductants, can cause the λ ratio to reach well below 1.

[0005] Lean NO_x traps, however, often have the problem of low NO_x conversion; that is, a high percentage of the NO_x slips through the trap as NO_x. NO_x slip can occur either during the lean portion of the cycle or during the rich portion. The lean NO_x slip is often called "NO_x breakthrough." It occurs during extended lean operation and is related to saturation of the NO_x trap capacity. The rich NO_x slip is often called a "NO_x spike." It occurs during the short period in which the NO_x trap transitions from lean to rich and is related to the release of stored NO_x without reduction. Test results depicted in FIG. 1a have

shown that during this lean-rich transition, NO_x spikes, the large peaks of unreacted NO_x accounts for approximately 73% of the total NO_x emitted during the operation of a lean NO_x trap. NO_x breakthrough accounts for the remaining 27% of the NO_x emitted.

[0006] An additional problem with lean NO_x traps arises as a result of the generation of ammonia by the lean NO_x trap. As depicted in FIG. 1b, ammonia is emitted into the atmosphere during rich pulses of the lean NO_x adsorber. In laboratory reactor experiments, ammonia spikes as high as 600 ppm have been observed under typical lean NO_x adsorber operation (see FIG. 1b). While ammonia is currently not regulated, ammonia emissions are being closely monitored by the U.S. Environmental Protection Agency; and, therefore, reduction efforts must be underway. Ammonia is created when hydrogen or hydrogen bound to hydrocarbons reacts with NO_x over a precious metal, such as platinum. The potential for ammonia generation increases for a precious metal catalyst (such as a lean NO_x trap) as the λ ratio is decreased, as the duration of the rich pulse increases, and the temperature is decreased. There is thus an optimum λ and rich pulse duration where the maximum NO_x reduction is observed without producing ammonia. Attempts to enhance conversion of NO_x by decreasing the λ ratio of the rich pulse duration leads to significant production of ammonia and thus results in high gross NO_x conversion ($\text{NO}_x \rightarrow \text{N}_2 \rightarrow \text{NH}_3$), but much lower net NO_x conversion ($\text{NO}_x \rightarrow \text{N}_2$).

[0007] In addition to nitrogen, a desirable non-polluting gas, and the undesirable NH₃ described above, N₂O is another NO_x reduction products. Like NH₃, N₂O is generated over NO_x adsorbers and emitted into the atmosphere during rich pulses. The gross NO_x conversion is the percent of NO_x that is reduced to N₂, N₂O and N₃. The net NO_x conversion is the percent of NO_x that is reduced to nitrogen, N₂, only. Accordingly, the gross NO_x conversion is equal to the net NO_x conversion if nitrogen is the only reaction product. However, the net NO_x conversion is almost always lower than the gross NO_x conversion. Accordingly, a high gross NO_x conversion does not completely correlate with the high portion of NO_x that is reduced to nitrogen.

[0008] The NOx conversion problem is magnified for diesel vehicles, which require more than a 90% NOx conversion rate under the 2007 U.S. Tier II BIN 5 emissions standards at temperatures as low as 200°C. While high NOx activity is possible at 200°C, it requires extreme measures such as shortening the lean time, lengthening the rich purge time, and invoking very rich air/fuel ratios. All three of these measures, however, result in the increased formation of NOx or ammonia. Accordingly, while it may be possible to achieve 90+% gross NOx conversion at 200°C, to date there has not been a viable solution to achieve 90+% net NOx conversion.

[0009] Accordingly, a need exists for a catalyst system that eliminates NOx breakthrough during the lean operation as well has the NOx spikes during the lean-rich transition period. There is also a need for a catalyst system that is capable of improving net NOx conversion. Finally, there is a need for a catalyst system capable of reducing ammonia emissions.

SUMMARY OF THE INVENTION

[0010] This invention provides a solution for all of the above problems and, in particular, reduces or eliminates ammonia emissions and improves the net NO_x conversion of the catalyst system. These problems are solved by simultaneously removing ammonia and enhancing NO_x conversion with the use of an NH₃-SCR catalyst placed downstream of the lean NO_x adsorber catalyst, as shown in FIG. 2. The NH₃-SCR catalyst system serves to adsorb the ammonia emissions from the upstream lean NO_x adsorber catalyst generated during the rich pulses. Accordingly, as shown in FIG. 2, the ammonia emissions produced by the lean NO_x adsorber is stored and effectively controlled by the NH₃-SCR catalyst rather than being emitted. This reservoir of adsorbed ammonia then reacts directly with the NO_x emitted from the upstream lean NO_x adsorber. As a result, as shown in FIG. 3, the overall net conversion is enhanced from 55% to 80%, while depleting the stored ammonia, as a function of the SCR reaction: $\text{NH}_3 + \text{NO}_x \rightarrow \text{N}_2$. The NH₃-SCR catalyst is then replenished with ammonia by subsequent rich pulses over the lean NO_x adsorber.

[0011] During the lean cycle for this lean NO_x adsorber+NH₃-SCR system, the NO_x breakthrough from the upstream lean NO_x adsorber is reduced continuously as it passes over the NH₃-SCR until the reservoir of ammonia is depleted. In addition, during the rich cycle, large spikes of unreacted NO_x, are created. The downstream NH₃-SCR catalyst thus serves to dampen these large NO_x spikes by reacting the unreacted NO_x with the reservoir of stored ammonia emitted from the lean NO_x adsorber. In general, the combination of the lean NO_x adsorber+NH₃-SCR catalyst system allows for the reduction, or elimination, of ammonia emissions and NO_x slip, i.e., reduction of NO_x breakthrough and NO_x spikes and, therefore, improved net NO_x conversion during lean and rich operation.

[0012] Additionally, under this invention, urea and/or ammonia does not need to be injected into the exhaust system to effectuate the reaction between NO_x and ammonia. Rather, the ammonia is automatically generated from the NO_x present in the exhaust gas as it passes over the precious metal lean NO_x adsorber during the rich pulses. The generated ammonia is then stored on the downstream NH₃-SCR catalyst, to react with the unreacted NO_x and thereby convert the unreacted NO_x to nitrogen.

[0013] The NH₃-SCR catalyst thus serves to adsorb the ammonia from the upstream lean NO_x adsorber catalyst generated during the rich pulses. Under this system, the ammonia is stored and effectively controlled rather than being emitted. This reservoir of adsorbed ammonia then reacts directly with any NO_x emitted from the upstream lean NO_x adsorber. As a result, the overall net NO_x conversion is enhanced from 55% to 80%, while the overall gross NO_x conversion is enhanced from 68% to 82%, as shown in FIG. 3.

[0014] In one alternative embodiment of this invention, the catalyst system can be optimized and NO_x reduction increased by vertically slicing the lean NO_x trap and NH₃-SCR catalyst substrates to create separate catalyst zones, such that the catalytic converter shell or can would have alternating sections of lean NO_x trap and NH₃-SCR catalysts, as shown in FIGS. 4a, 4b and 4c. Under this embodiment, both technologies, the lean NO_x trap formulation and the NH₃-SCR formulation, can be incorporated into a single substrate

and/or a single converter can rather than placing the NH_3 -SCR catalyst downstream of the lean NO_x adsorber as two separate and distinct catalyst substrates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1a is a graph illustrating the NO_x spikes that occur during the NO_x trap lean-rich transition;

[0016] FIG. 1b is a graph illustrating NO_x and NH_3 emissions from a typical prior art lean NO_x adsorber system;

[0017] FIG. 2 depicts the lean NO_x and NH_3 -SCR catalyst system of the present invention;

[0018] FIG. 3 depicts reduced NO_x emissions and NH_3 emissions as a result of the use of the lean NO_x and NH_3 -SCR catalyst system of the present invention, as shown in FIG. 2;

[0019] FIGS. 4a, 4b, and 4c depict three different zoned catalyst embodiments of the lean NO_x and NH_3 -SCR catalyst system;

[0020] FIGS. 5a, 5b, and 5c provide graphs illustrating the reduced levels of NO_x and NH_3 emissions resulting from each of the three zoned catalyst embodiments depicted in FIGS. 4a, 4b, and 4c at a 250°C inlet gas temperature and operating at a 50 second lean cycle and 5 second rich cycle;

[0021] FIGS. 6a, 6b and 6c provide graphs illustrating the reduced levels of NO_x and NH_3 emissions resulting from each of the three zoned catalyst embodiments depicted in FIGS. 4a, 4b and 4c at a 200°C . inlet gas temperature and operating at a 25 second lean cycle and a 5 second rich cycle;

[0022] FIGS. 7a, 7b and 7c show three proposed examples of washcoat configurations incorporating the lean NO_x trap and NH_3 -SCR formulations into the same substrate;

[0023] FIG. 8 is a graph illustrating the impact of NO_x conversion after hydrothermal aging; and

[0024] FIG. 9 depicts a modified three-way catalyst and NH₃-SCR catalyst system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] In this invention, net NO_x conversion is improved and ammonia emissions reduced through the use of a lean NO_x trap and NH₃-SCR catalyst system which operate together to produce and store ammonia and reduce NO_x to nitrogen. In so doing, the catalyst system of the present invention solves three problems of lean NO_x traps; namely, reducing NO_x breakthrough, NO_x spikes and ammonia emissions.

[0026] In order to meet increasingly stringent fuel economy standards, it is preferable to operate an automotive engine under lean conditions. However, while there is improvement in fuel economy, operating under lean conditions has increased the difficulty in reducing NO_x emissions. As an example, for a traditional three-way catalyst, if the air/fuel ratio is lean even by a small amount, NO_x conversion drops to low levels. With traditional three-way catalysts, the air/fuel ratio must be controlled carefully at stoichiometric conditions to maximize reduction of hydrocarbons, carbon monoxide and NO_x.

[0027] Throughout this specification, NO_x refers to nitrogen oxides, which include nitrogen monoxide NO and nitrogen dioxide NO₂. Further, lean NO_x adsorber and lean NO_x trap are used interchangeably throughout this specification.

[0028] To achieve NOx reduction, under lean operating conditions, one option is the inclusion of a lean NOx trap. While the lean NOx trap is generally effective in NOx reduction, lean NOx traps are known to have the problems referred to as "NOx slip" which includes breakthrough of NOx during the extended lean operation of the NOx trap and also NOx spikes generated during the transition from the lean to the rich cycle.

[0029] NOx spikes, or NOx emissions during the lean-rich transition, are believed to occur due to the exothermic heat generated from the oxidation of reductants, carbon

monoxide, hydrocarbons and hydrogen, by the oxygen released from the oxygen storage material-the temperature rise can be as high as 80-100°C.

[0030] The problem of NO_x spikes is illustrated in FIG. 1a, and the problem of insufficient net NO_x conversion is illustrated in FIG. 1b. FIG. 1b depicts laboratory reactor data of a lean NO_x adsorber system operating in an 85 second lean and 5 second rich cyclic pattern. The plot in FIG. 1b shows the nitrogen species concentration as a function of time. The laboratory reactor data depicted in FIG. 1b resulted from a catalyst having an engine swept volume (ESV) of 100%. Additionally, the reactor used to obtain the results in FIG. 1b was at a temperature of 300°C. To begin the cycle, 500 ppm of nitrogen oxide was fed into the reactor where much of it was stored during the 85 second lean duration. During the 5 second rich duration, nitrogen oxide was reduced; however, a significant amount of ammonia was formed. As illustrated in FIG. 1b, the data shows ammonia spikes as high as 600 ppm under typical lean NO_x adsorber operation. Conversion, however, is generally improved as the λ ratio is decreased during the rich pulse. Decreasing the λ ratio also leads to significant production of ammonia and thus results in high gross NO_x conversion ($\text{NO}_x \rightarrow \text{N}_2 + \text{NH}_3$), but much lower net NO_x conversion ($\text{NO}_x \rightarrow \text{N}_2$). As illustrated in FIG. 1b, the net NO_x conversion to nitrogen for this lean NO_x adsorber system was only 55%.

[0031] Under the catalyst system of this invention, ammonia is reduced and the net NO_x conversion improved simultaneously by placing an NH₃-SCR catalyst formulation downstream of the lean NO_x adsorber catalyst, as shown in FIG. 2.

[0032] FIG. 2 is an illustration of the catalyst system of this invention, which is capable of simultaneously eliminating ammonia emissions and improving net NO_x conversion. As illustrated in FIG. 2, NO_x produced during engine operation is stored by the lean NO_x adsorber during the lean cycle. Following the lean cycle, during the rich cycle of the lean NO_x adsorber NO_x is reduced and ammonia generated. The lean NO_x adsorber stores much of the NO_x during the lean operation and then reduces NO_x during rich pulses of the reductants. During the same rich pulses, significant amounts of ammonia are generated, as further illustrated in FIG. 1. As illustrated in FIG. 2, the lean NO_x adsorber

emits NO, NO₂, NH₃, and N₂O. These same gases then pass through the NH₃-SCR, where NH₃ is stored. Accordingly, the addition of the NH₃-SCR catalyst downstream allows for the adsorption of NH₃ and subsequent reaction with any NO_x that slips through the upstream lean NO_x adsorber, which thus improves the overall net NO_x conversion (NH₃+NO→N₂). As can be seen in FIG. 2, the catalyst system of this invention results in a significant net NO_x conversion improvement, the elimination of ammonia emissions, and the production of non-polluting gases nitrogen and N₂O.

[0033] It should be noted that for diesel applications, lean NO, NO_x adsorbers must operate at lower temperatures compared to gasoline lean NO_x adsorbers since the exhaust temperatures of diesel engines are significantly lower. More ammonia is generated at 200°C than at 300°C. over lean NO_x adsorbers and thus the catalyst system of this invention has an even greater potential for diesel applications. Likewise, the problem of NO_x spikes is more critical at higher temperatures, the temperatures used for gasoline applications; and thus the catalyst system of this invention is beneficial to control the unreacted NO_x spikes that result from the operation of a lean NO_x adsorber at operating temperatures typical for gasoline lean NO_x adsorber applications.

[0034] The NH₃-SCR catalyst thus serves to adsorb the ammonia produced naturally from the upstream lean NO_x adsorber catalyst generated during the rich pulses. As a result, the NH₃-SCR catalyst stores the ammonia, controlling it rather than allowing it to be emitted into the atmosphere. This reservoir of adsorbed NH₃ in the NH₃-SCR catalyst reacts directly with the NO_x emitted from the upstream lean NO_x adsorber (trap).

[0035] In general, this invention works to clean NO_x emissions-and thus has applicability for stationary sources as well as for moving vehicles. This invention may be used to reduce NO_x emissions for nitric acid plants, or any other stationary source that requires the reduction of NO_x emissions. This invention is nonetheless particularly directed for use with gasoline and diesel vehicles which, unlike stationary sources, have a wide range of operating parameters, especially temperature parameters-which cannot be precisely controlled. The present invention has the ability to store large quantities of ammonia across

a broad temperature range to effectuate the reaction between ammonia and nitrogen oxides and thereby convert NOx to nitrogen.

[0036] As illustrated in FIG. 3, laboratory experiments have demonstrated that the use of a lean NOx adsorber plus NH₃-SCR catalyst system improves net NOx conversion from 55%, as illustrated in FIG. 1, to 80%. FIG. 3 is a graph displaying laboratory data obtained using the catalyst system of this invention, wherein NOx ppm are charted as a function of time. As illustrated in FIG. 3, the catalyst system of this invention completely eliminated the ammonia spikes created during the rich pulses of the lean NOx adsorber. In this system, ammonia is stored on the NH₃-SCR catalyst where it reacts with NOx during the 85 second lean duration, which thus improves the net NOx conversion from 55% to 80% with no additional fuel economy penalty. As shown in FIG. 3, the improved net NOx conversion can be observed by the much narrower profile-zero ppm NOx is emitted for a significant amount of time as compared to the graph shown in FIG. 1 of a system lacking the NH₃-SCR+lean NOx adsorber combination.

[0037] The reaction between the stored ammonia and NOx increases the overall net NOx conversion, which is enhanced from 55%-the amount of NOx converted in prior art lean NOx trap systems-to 80%-as a result of the combination of a lean NOx trap and NH₃-SCR catalyst system. Moreover, in addition to improving net NOx conversion, the ammonia stored in the NH₃-SCR catalyst is depleted during the SCR reaction wherein ammonia and nitrogen oxide are reacted to produce nitrogen. The NH₃-SCR catalyst is replenished with ammonia by subsequent rich pulses over the lean NOx adsorber that causes a portion of the NOx to react with hydrogen to form ammonia.

[0038] It should be noted that no urea or ammonia needs to be injected into the exhaust system to effectuate the reaction between ammonia and NOx. Rather, the ammonia is naturally generated from the NOx present in the exhaust gas as it passes over the lean NOx trap during rich pulses. More specifically, ammonia is naturally created during the fuel rich cycle of the lean NOx trap. Ammonia is naturally produced as it passes over the precious metal active component of the lean NOx trap. Similarly, the ammonia could also be

generated in a conventional precious metal based TWC located upstream of a LNT/ NH₃-SCR system.

[0039] For this invention, the lean NO_x trap is optimized for ammonia generation by removing oxygen storage capacity (OSC) and thereby enhancing the rich cycle and thus creating a greater quantity of ammonia for reaction with the NO_x in the downstream NH₃-SCR catalyst. In a preferred embodiment, the lean NO_x trap includes platinum as the precious metal. Platinum is the preferred precious metal because it is believed that a greater quantity of NH₃ is produced over platinum than rhodium, palladium and/or a combination of the precious metals. Nonetheless, other precious metals such as palladium and rhodium, and the combination of one or more of the precious metals platinum, palladium and rhodium may also be used to generate NH₃.

[0040] Additionally, the lean NO_x trap of this invention preferably includes a "VNO_x adsorbing material" or NO_x storage component/material, which can be alkali and alkali earth metals such as barium, cesium, and/or rare earth metals such as cerium and/or a composite of cerium and zirconium. Although an alternative catalyst formulation that does not contain a NO_x storage component but generates ammonia from NO_x, may also be utilized, in the most preferred embodiment, the NO_x storage material should have the ability to store NO_x at low temperature ranges, specifically in the range of 150°C-300°C. The NH₃ thermodynamic equilibrium under rich conditions is maximized during the temperature range of 150°C-300°C.

[0041] In general, to increase the NO_x storage function of the lean NO_x trap and effectuate the NO_x conversion reaction, in the preferred embodiment, the lean NO_x trap has the following characteristics: (1) the inclusion of platinum as the precious metal; (2) the ability to store NO_x between 150°C and 500°C during the lean portion of the cycle; (3) the ability to maximize the duration of the lean NO_x trap rich cycle; (4) the ability to generate ammonia at the 150°C-500°C temperature range; (5) minimize OSC to lessen fuel penalty; and (6) lower λ to generate more ammonia. Ammonia production is maximized at the preferred temperature range, 150°C-300°C-which also correlates with the steady state

equilibrium range for ammonia creation. It bears emphasis that other NO_x storage components may be utilized, especially for stationary sources, where sulfur poisoning does not pose a threat.

[0042] Most simply, the NH_3 -SCR catalyst may consist of any material or combination of materials that can adsorb ammonia and facilitate the $\text{NO}_x + \text{NH}_3$ to yield nitrogen. The NH_3 -SCR catalyst should preferably be made of a base metal catalyst on a high surface area support such as alumina, silica, titania, zeolite or a combination of these. More preferably, the NH_3 -SCR catalyst should be made of a base metal selected from the group consisting of Cu, Fe, and Ce and/or a combination of these metals, although other base metals may be used. Base metals generally are able to effectuate NO_x conversion using ammonia while both the base metals and the high surface support material serves to store NH_3 . The base metal and high surface area support such as zeolite selected should preferably be one that can store NH_3 over the widest possible temperature range. Likewise, the base metal selected is preferably one that can convert NO and NO_2 to N_2 across the widest possible temperature range and the widest range of NO/ NO_2 ratios.

[0043] The advantage of the catalyst system of this invention is the use of a combination of a lean NOx trap and an NH₃-SCR catalyst. The use of a lean NOx trap in the present system allows for much greater storage of NOx R, because the NOx breakthrough that would otherwise happen can be controlled by the NH₃-SCR catalyst. Additionally, the use of a lean NOx trap as part of this system allows for the operation of the engine at lean conditions for a longer time and thus provides improved fuel economy. If, for example, a three-way catalyst is used as the NOx storage mechanism, NOx storage is significantly limited, as well as the production of ammonia. To maximize the reduction of emissions, a three-way catalyst must be operated at stoichiometric conditions. Accordingly, unless the three-way catalyst is run on the rich side 100% of the time, ammonia production is significantly less than for a typical lean NOx trap. As set forth above, the efficiency of a three-way catalyst is compromised if it is operated at conditions other than at stoichiometric

conditions. Thus, the combination of a lean NO_x trap and NH₃-SCR catalyst allows for significant NO_x storage and ammonia production and thus increases net NO_x conversion.

[0044] In a preferred embodiment, the lean NO_x trap and NH₃-SCR catalyst constitute alternating zones in a single substrate and/or a single catalytic converter can. This zoned design, as shown in three different embodiments in FIGS. 4a-4c, is believed to maximize the reaction between ammonia and NO_x.

[0045] As illustrated in FIG. 4, three zoned catalyst system embodiments were evaluated on a laboratory flow reactor. The total catalyst system dimensions were held constant at a 1" diameter and 2" length. The first system, labeled "4a", had a 1" long lean NO_x trap followed by a 1" long NH₃-SCR catalyst. In the second system, labeled "4b", the catalyst samples were sliced in half to yield alternating 1/2" long sections. Finally, in the third system, labeled "4c", the same catalyst samples were further cut in half to yield 1/4" long sections, again of the lean NO_x trap and NH₃-SCR catalyst technologies. It should be noted that each time the catalysts were sliced, as shown in "4b" and "4c", the overall length of the catalyst system was reduced slightly, approximately 3/16" total. The alternating lean NO_x trap and NH₃-SCR catalyst zones can be created in a single substrate or the lean NO_x trap and NH₃-SCR catalyst prepared, cut as desired and then placed adjacent one another in a single can. The zones are preferably formed in a single substrate. However, cut substrates placed in alternating fashion also exhibit improved net NO_x conversion.

[0046] Under the zoned catalyst designs shown in FIGS. 4a-4c, where alternating lean NO_x and NH₃-SCR catalyst zones are provided, the ammonia formed by the lean NO_x trap is believed to be immediately adsorbed by the NH₃-SCR catalyst for use in the NO_x conversion reaction. It is further believed that the greater the separation between the lean NO_x trap and the NH₃-SCR catalyst, the greater chance there is for the ammonia to be converted back into NO_x. It is further believed that oxygen is more abundant in the back of a catalyst substrate and thus the oxygen may be available to effectuate the unwanted conversion of the ammonia back to nitrogen oxide. Accordingly, if the catalyst substrate is too long, there may be some undesired conversion that takes place; and thus in a preferred

embodiment, the substrate is designed so that ammonia is available for immediate reaction with NO_x.

[0047] FIGS. 5a-5c illustrate laboratory reactor data of the three different zoned catalyst system embodiments shown in FIGS. 4a-4c. This laboratory data was obtained with the three catalyst systems operating at a 250°C inlet gas temperature and operating with 50 second lean and 5 second rich cycles. Additionally, the inlet concentration of the NO_x feed gas was 500 ppm and the overall space velocity was 15,000 per hour. As illustrated in FIGS. 5a-5c, with the use of a two-zoned catalyst system as depicted in FIG. 5a, approximately 50 ppm of NO is emitted. This two-zone catalyst system resulted in a gross NO_x conversion of 95% and a net NO_x conversion of 66%. The four-zone catalyst embodiment, depicted as FIG. 5b, significantly reduced NO_x emissions, well below the 15 ppm range, to result in gross NO_x conversion of 99% and a net NO_x conversion of 86%. Finally, as illustrated by the eight zoned catalyst embodiment, FIG. 5c, gross NO_x conversion is 100% and net NO_x conversion is 97.5%. The improvement comes from the reduction of N₂O elimination of the NH₃ breakthrough and reduction of NO_x. Accordingly, as the catalyst system is zoned down from 1" sections to 1/4" sections, the test results revealed an associated improvement in net NO_x conversion.

[0048] As shown in FIGS. 5a-5c, a zoned catalyst, with alternating lean NO_x and NH₃-SCR catalysts in 1" to 1/4" sections significantly improves the net NO_x conversion from 66% to 97.5%. In addition, the gross NO_x conversion is improved from 95% to 100%. In general, the improvement in the net NO_x conversion is the function of the elimination of the ammonia slip, reduction in N₂O, and extra NO_x reduction related to the NH₃ + NO_x reaction on the NH₃-SCR catalyst. It is further believed that the drop in N₂O emissions is likely due to a higher fraction of the NO_x reduction reaction proceeding on the NH₃-SCR catalyst rather than the lean NO_x trap. NO_x reduction over a platinum-containing-lean NO_x trap results in high levels of N₂O generation, whereas the NH₃-SCR catalyst has a high selectivity to nitrogen.

[0049] FIGS. 6a-6c depicts laboratory data obtained using the three-zoned catalyst embodiments originally shown in FIGS. 4a-4c at a 200°C inlet gas temperature operating with a 25 second lean cycle and a 5 second rich cycle. As compared to FIGS. 5a-5c, it should be noted that shortening the lean time from 50 seconds, as used in FIGS. 5a-5c, to 25 seconds, resulted in a substantial higher steady emission of ammonia—a fact which results in reduced net NO_x conversion rates, as compared to the data charted in FIGS. 5a-5c. As can be seen in FIGS. 6a-6c, the use of smaller zoned sections from two zones to eight zones and thus 1" sections down to 1/4" sections, as illustrated in FIGS. 6a and 6c, improves the net NO_x conversion from 50% to 81%. Again, this improvement is believed to come mainly from the reduction of ammonia breakthrough and a small reduction in N₂O emissions. This lab data was obtained with an inlet concentration of the NO_x feed gas at 500 ppm and an overall space velocity at 15,000 per hour.

[0050] As set forth above, in the preferred embodiment, the lean NO_x trap washcoat and NH₃-SCR washcoat are combined in a single substrate rather than placing the NH₃-SCR formulation downstream of the lean NO_x adsorber as two separate catalyst substrates. Under this embodiment, the catalyst formulations can be incorporated together by mixing or layering the washcoats on a substrate.

[0051] FIGS. 7a-7c show three proposed washcoat configurations incorporating the lean NO_x trap and NH₃-SCR formulations into the same substrate. As shown in FIGS. 7a and 7b, the first and second proposed configurations have the lean NO_x trap and NH₃-SCR washcoat formulations on the bottom and top layer, respectively. It is believed that the top layer could be a highly porous structure that allows better and faster contact between the chemicals and gas phase and the active sites in the second layer. The third configuration, as shown in FIG. 7c, involves the use of a one layer washcoat containing both lean NO_x trap and NH₃-SCR washcoat formulations. Under this third configuration, shown in FIG. 7c, the washcoat composition of the lean NO_x trap and NH₃-SCR catalyst could be homogeneously or heterogeneously mixed. For a heterogeneously mixed composition, the formulation of the lean NO_x trap and NH₃-SCR catalyst are separated. However, they contact each other in

varying degrees by controlling the size of the grain structures. The homogeneously mixed composition allows for a more intimate contact between the two formulations and is thus preferred.

[0052] The invention also contemplates engineering such combinations within the pores of the monolithic substrate. An example of this is incorporating washcoat into porous substrates used for filtering diesel particulate matter. Thus, this lean NO_x trap/ NH₃-SCR catalyst concept can be integrated into diesel particulate matter devices.

[0053] This very active SCR reaction of NO_x and ammonia proceeds with or without oxygen present. Koebel et al. reports that the fastest SCR reaction involves equal molar amounts of NO and NO₂. NO and NO₂ then react with two NH₃ to yield N₂ in the absence of oxygen. In contrast, the lean NO_x adsorber reaction of NO_x plus CO is highly reactive only in an oxygen-free environment. In a lean NO_x adsorber system, NO_x is adsorbed during the lean cycle duration, NO_x is not reduced. Accordingly, NO_x reduction is limited to only the rich pulse time duration. On the other hand, the lean NO_x adsorber+NH₃-SCR catalyst system allows for NO_x reduction reaction to proceed during both the lean and rich time durations. Accordingly, ammonia as a reductant can be considered as a much more robust reductant than carbon monoxide.

[0054] As set forth above, the fastest SCR reaction involves equal molar amounts of NO and NO₂. Accordingly, FIG. 8 illustrates the impact of varying NO: NO₂ ratios after hydrothermal aging. FIG. 8 is a graph of three NH₃-SCR catalyst formulations over a wide NO: NO₂ range. In the laboratory, it was possible to control the NO: NO₂ ratio entering the downstream NH₃-SCR catalyst. Accordingly, the NO: NO₂ ratio entering the NH₃-SCR catalyst was solely dependent on the upstream lean NO_x adsorber. In some cases, the majority of the feed NO_x (especially NO_x spikes) are made up of mostly NO rather than NO₂. Accordingly, it is believed that the catalyst formulations of this invention will enhance reported net NO_x efficiency-and thus the preferred catalyst is one that is capable of operating across the broadest range of NO: NO₂ ratios, and at a full spectrum of temperature ranges.

[0055] In general, since NH_3 -SCR catalysts do not contain precious metals, they are significantly less costly than a typical lean NO_x trap. Accordingly, it is more cost effective to have an overall catalyst system containing a lean NO_x trap adsorber and an NH_3 -SCR catalyst system, rather than one that uses two lean NO_x trap adsorbers. Additionally, the incorporation of both a lean NO_x trap and NH_3 -SCR washcoat into a single substrate will significantly reduce substrate costs.

[0056] In another embodiment of this invention, NH_3 and NO_x in an exhaust stream are reduced using a stoichiometric three-way catalyst system. This three-way catalyst system has particular application for high speed/high flow rate conditions (i.e., US06 conditions). Currently, three three-way catalysts are used for such high speed condition applications, wherein the third three-way catalyst is primarily directed to NO_x removal for high speed/high flow rate conditions. Under this alternate embodiment, the third three-way catalyst can be substituted with an NH_3 -SCR catalyst to store NH_3 for reaction with NO_x to improve net NO_x conversion, eliminate NH_3 emissions and reduce catalyst costs.

[0057] To improve net NO_x and NH_3 reduction, the second three-way catalyst can be modified to enhance the three-way catalyst's ability to generate NH_3 emissions. To this end, in a preferred embodiment, the three-way catalyst is designed to generate desirable NH_3 creation by using platinum as the precious metal of the three-way catalyst, by placing platinum on the outer layer of the three-way catalyst to maximize the $\text{NO} + \text{H}_2 \rightarrow \text{NH}_3$ reaction. Likewise, the oxygen storage capacity (OSC) of the three-way catalyst can be removed to further promote the creation of "desirable" NH_3 . By doing so, the NH_3 purposely generated during rich operation can then be stored by the NH_3 -SCR catalyst for subsequent reaction with NO_x emissions, and thereby control both NO_x and NH_3 emissions under all operating conditions.

[0058] When a car is operated under rich conditions, the air/fuel ratio is less than 14.6, hydrogen is produced in the exhaust via the water-gas shift reaction:
 $\text{CO} + \text{H}_2\text{O} \rightarrow \text{CO}_2 + \text{H}_2$. The hydrogen that is produced then reacts with NO_x , as it passes over the precious metal surface to create "desirable" ammonia. The ammonia produced is then

stored on an NH_3 -SCR catalyst to help reduce net NO_x conversion. The reaction of $\text{NO}_x + \text{NH}_3 \rightarrow \text{N}_2 + \text{H}_2\text{O}$ can then take place on a separate NH_3 selective catalyst, capable of converting NO_2 and NO to N_2 .

[0059] As shown in FIG. 9, a stoichiometric three-way catalyst/ NH₃-SCR catalyst system 10 is depicted, including a first three-way catalyst 14 positioned in close proximity to the engine 12 to reduce cold start emissions. The second three-way catalyst 16 is modified as described above to enhance the ability of the second three-way catalyst 16 to generate NH₃ emissions. Downstream of the second three-way catalyst 16 is an NH₃-SCR catalyst 18 that functions to store NH₃ produced by the modified second three-way catalyst 16 for reaction with NO_x emissions, to reduce both NO_x and NH₃ emissions.

[0060] By substituting the third three-way catalyst as currently used with an NH₃-SCR catalyst and thereby eliminating the need for a third precious metal containing catalyst, significant cost savings can be achieved.

[0061] It should further be noted that this invention also contemplates the use of a three-way catalyst, in combination with a lean NO_x trap and an NH₃-SCR catalyst.

[0062] While the best mode for carrying out the invention has been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention as defined by the following claims.

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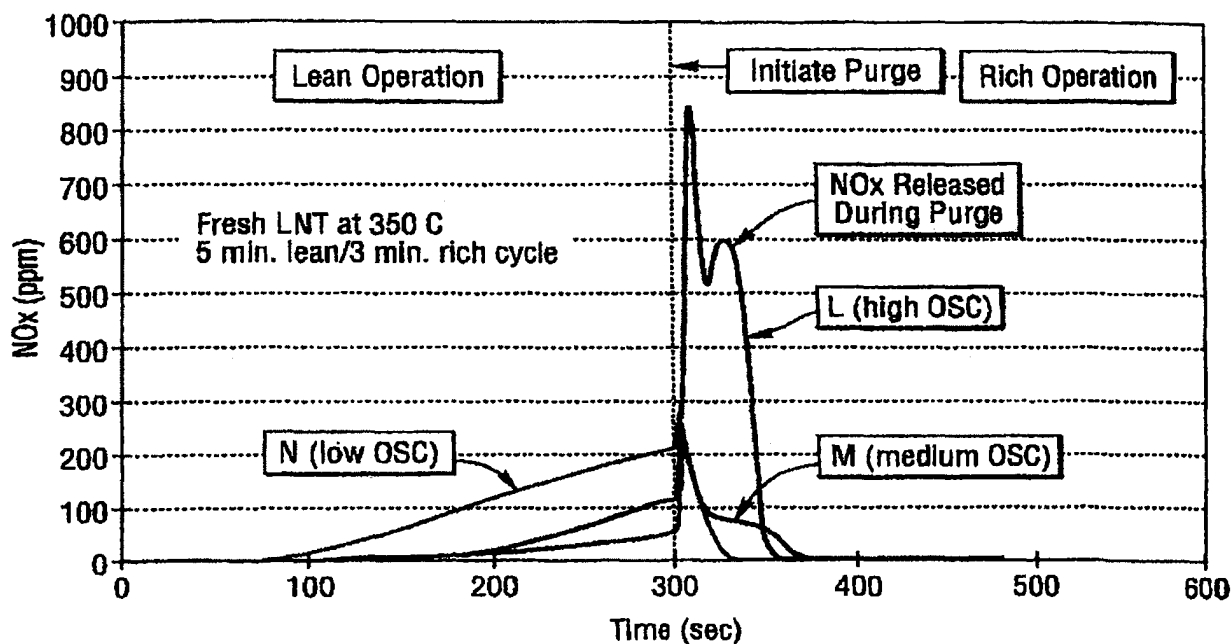


Fig. 1a

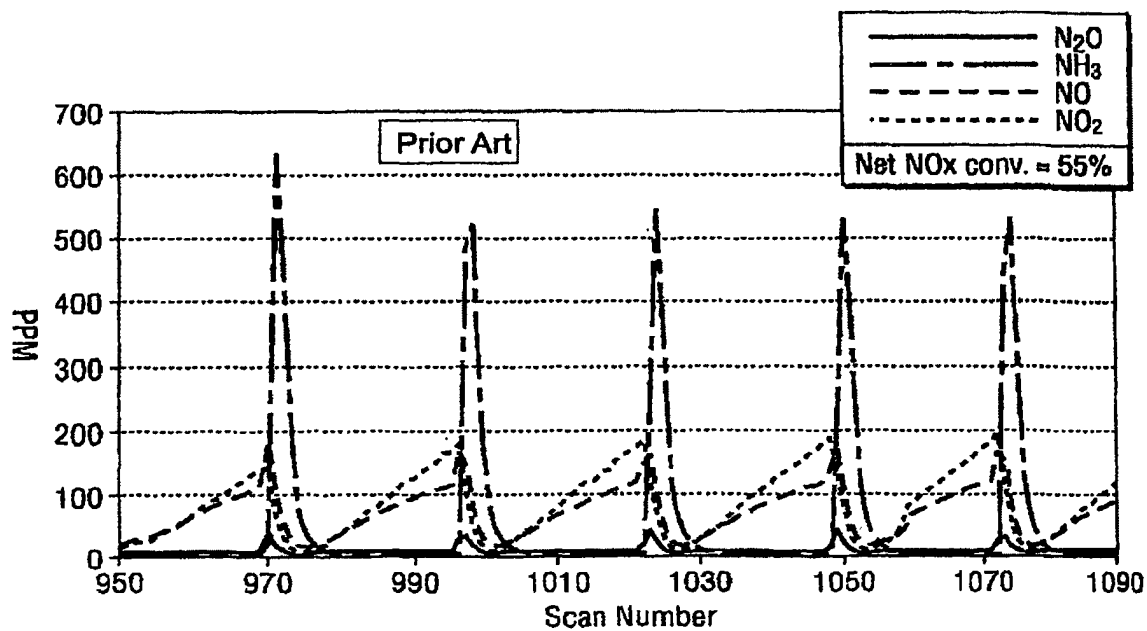


Fig. 16

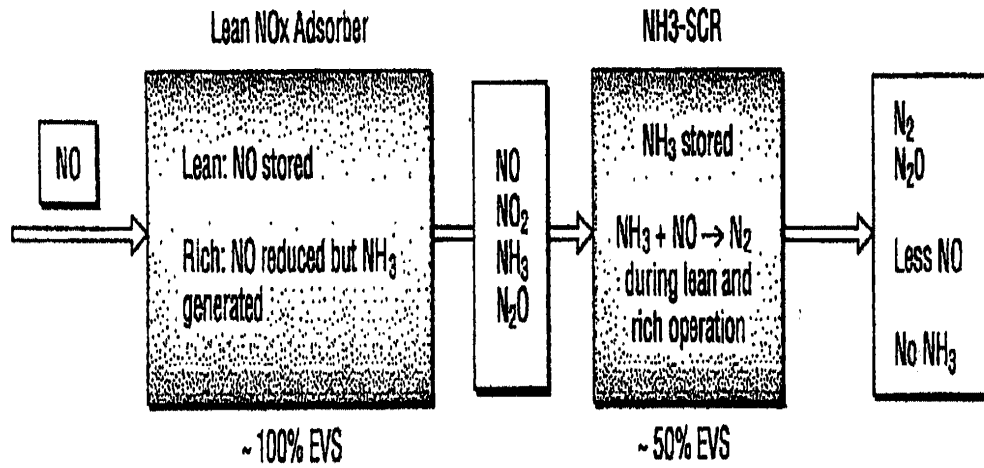
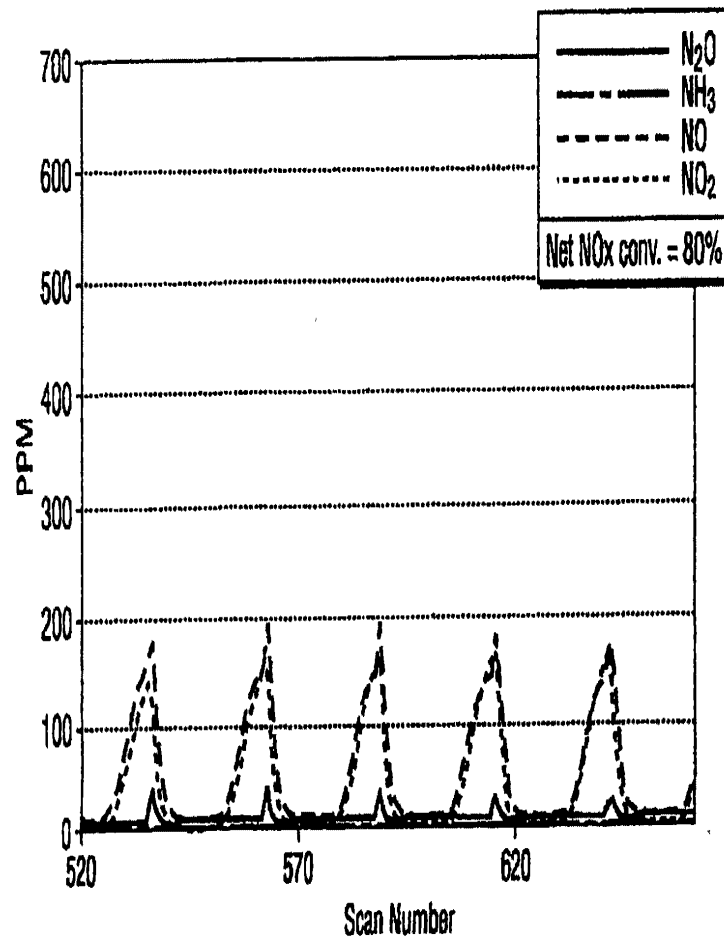


Fig. 2

Fig. 3



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Fig. 4a

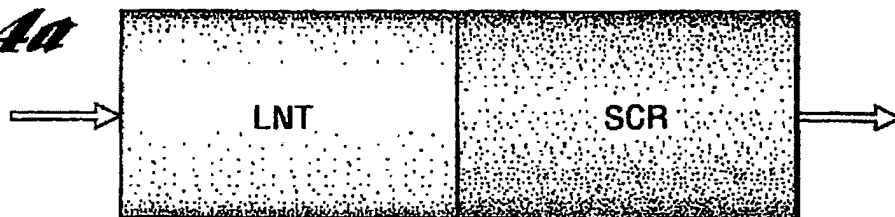


Fig. 4b

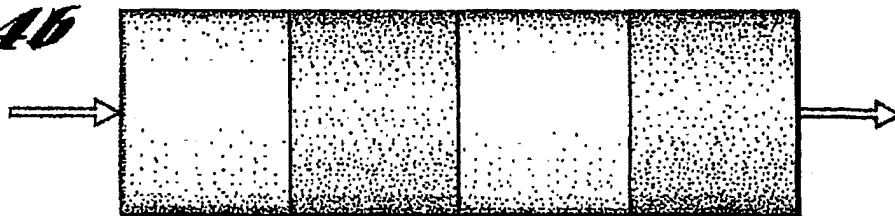
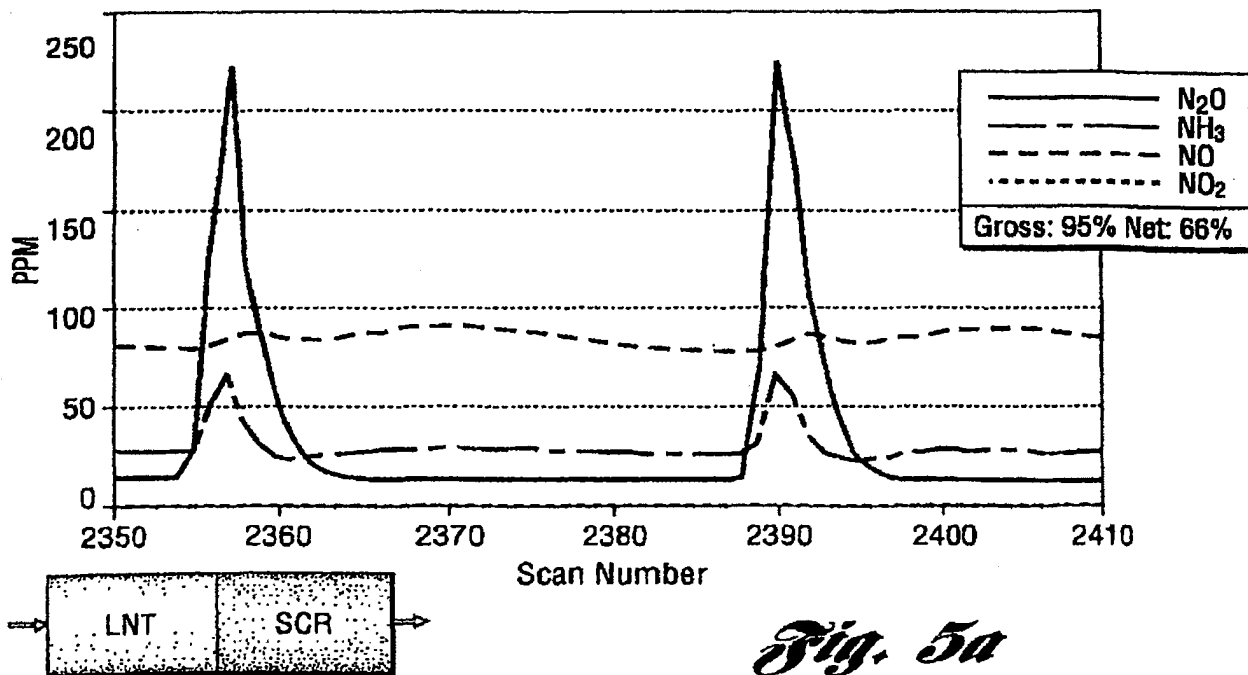
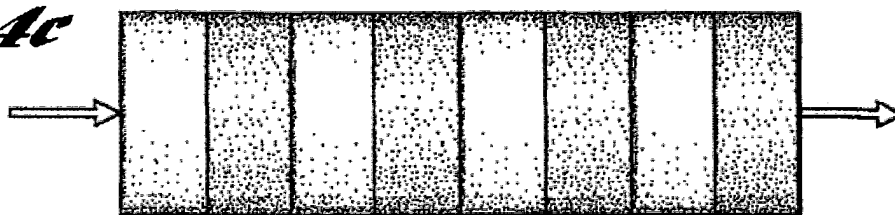
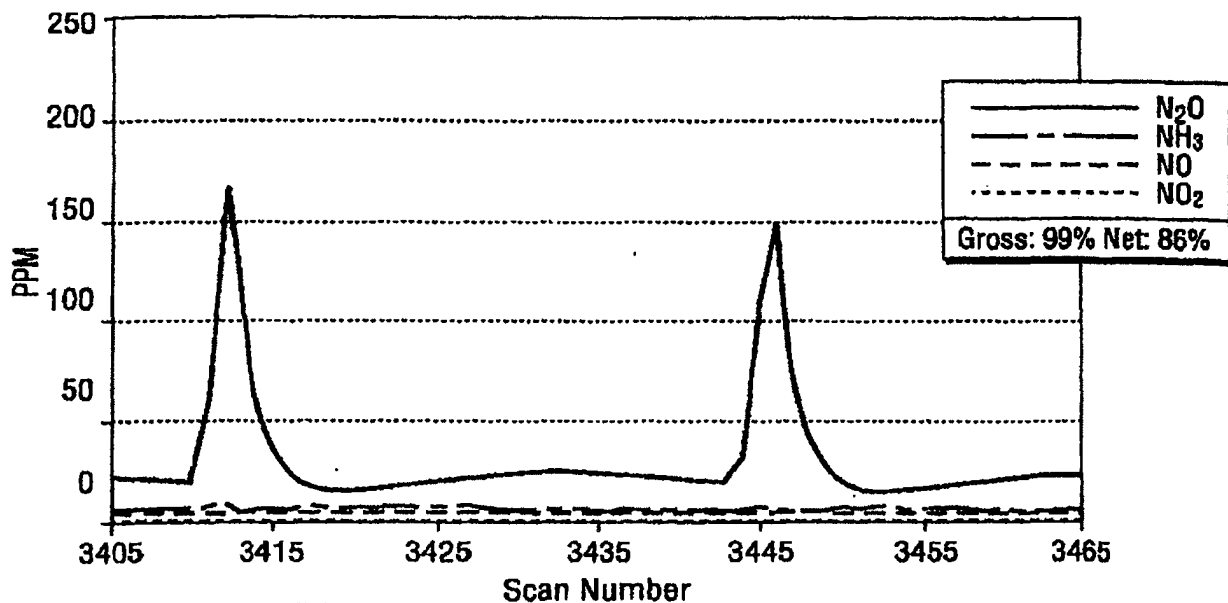


Fig. 4c



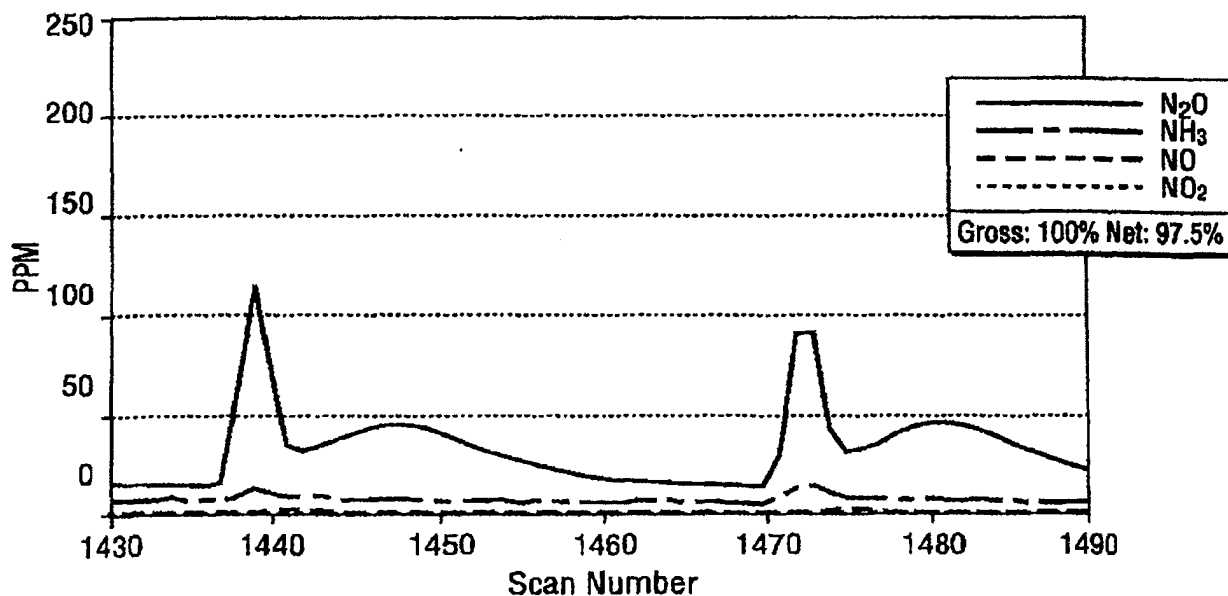
T = 250C
 L = 50s, 5s rich

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T = 250C
 L = 50s, 5s rich

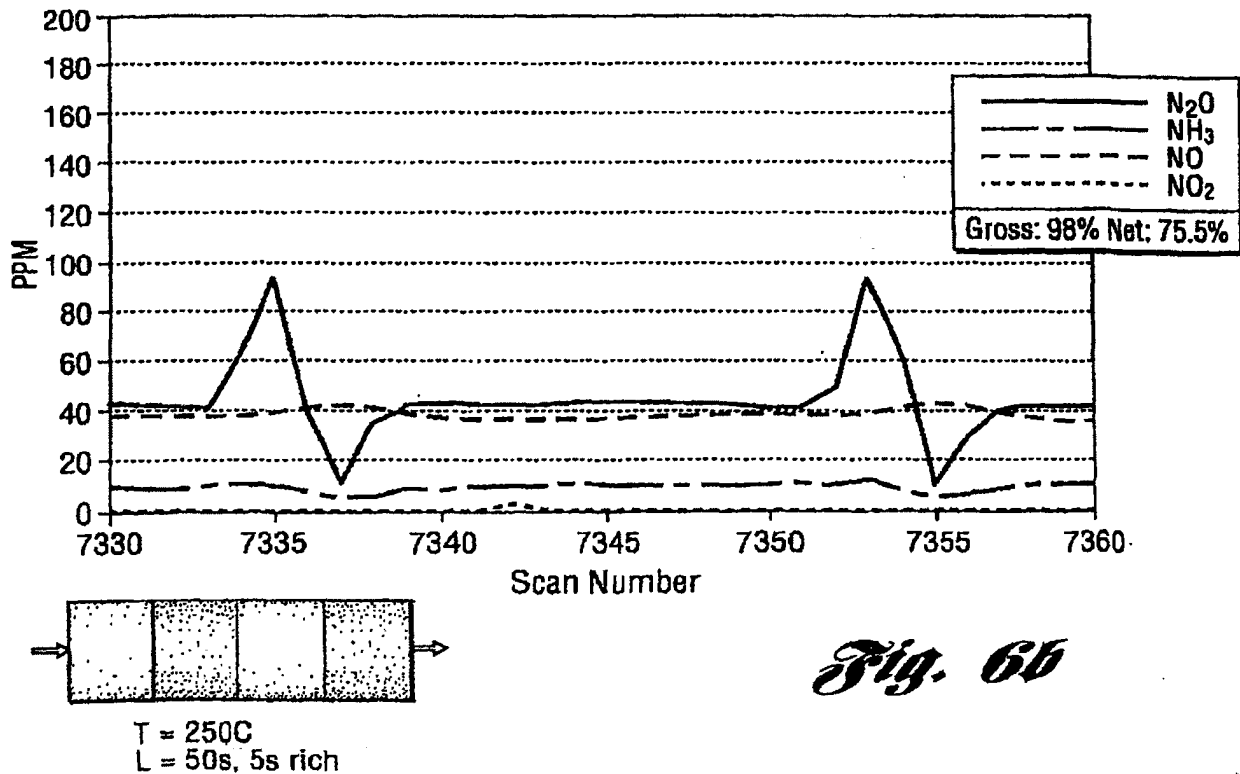
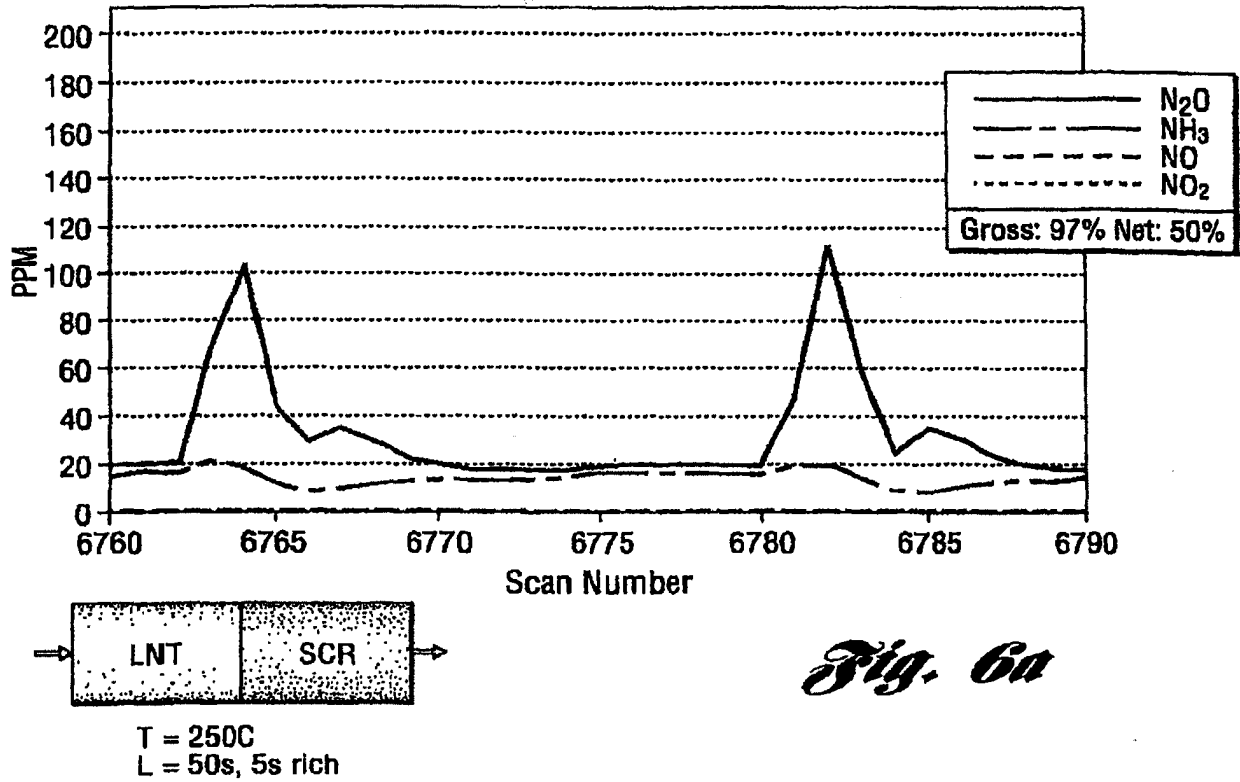
Fig. 5b



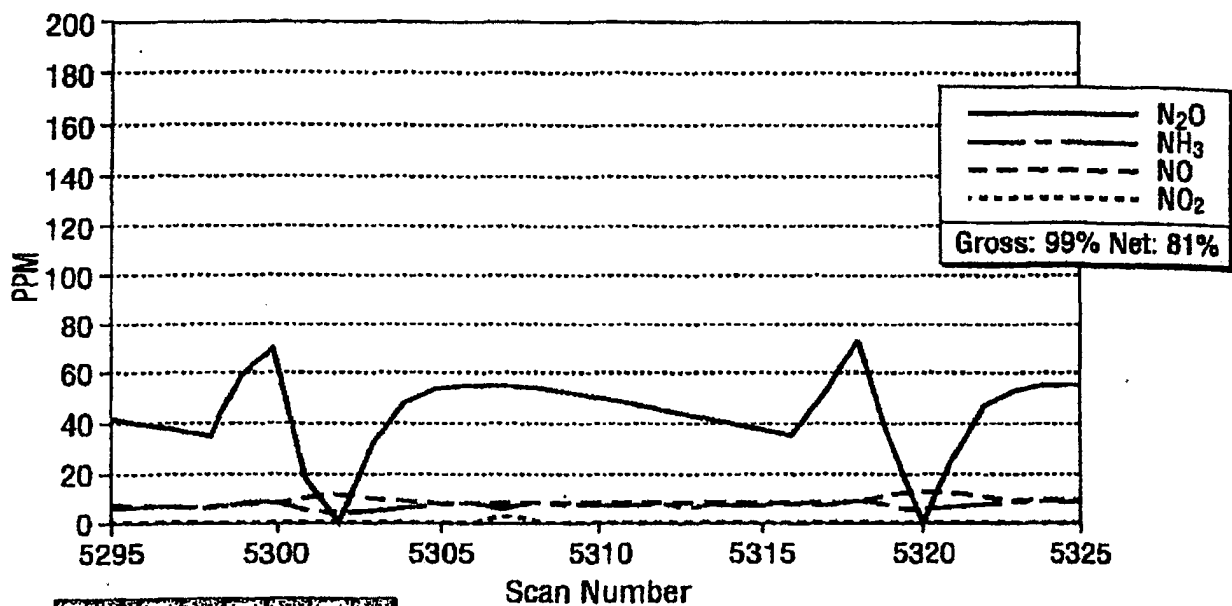
T = 250C
 L = 50s, 5s rich

Fig. 5c

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T = 200C
 L = 25s, 5s rich

Fig. 6c

Fig. 7a

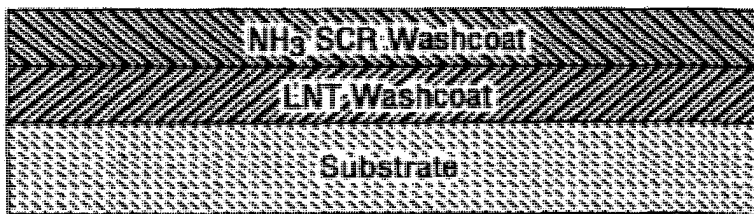


Fig. 7b

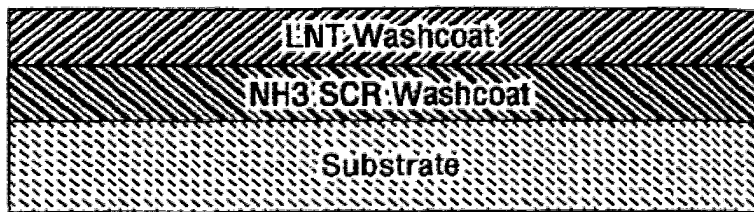
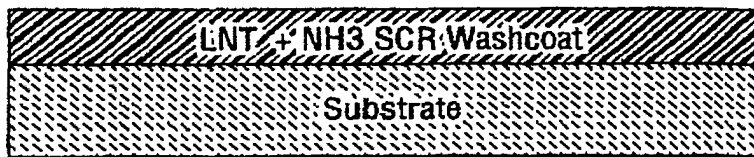


Fig. 7c



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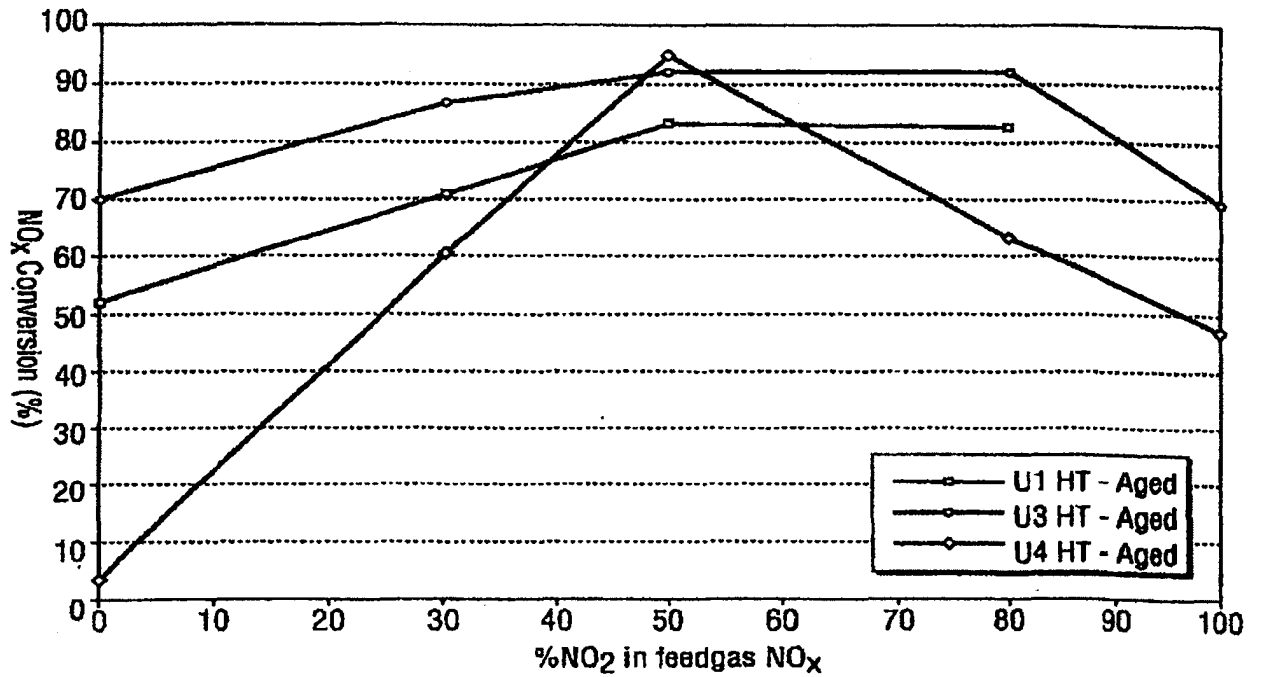


Fig. 8

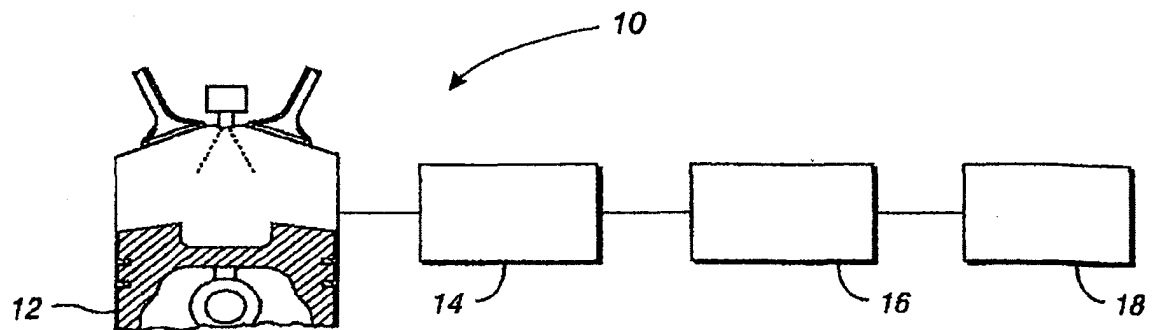


Fig. 9

CERTIFICATE OF SERVICE

I hereby certify that on this 13rd day of January, 2014, the foregoing BRIEF OF APPELLANTS was filed electronically with the U.S. Court of Appeals for the Federal Circuit by means of the Court's CM/ECF system. I further certify that the foregoing was served by means of electronic mail as well as by the Court's CM/ECF system, which should have sent a Notice of Docket Activity, upon the following counsel of record for Cross-Appellants:

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